AQUACULTURE ASSOCIATION OF CANADA

ASSOCIATION AQUICOLE DU CANADA

CONSEIL DES PRODUCTIONS ANIMALES DU QUÉBEC

4e ASSEMBLÉE ANNUELLE
4th ANNUAL MEETING

DOSSIER CONFÉRENCES

Sessions thématiques
Thematic sessions

Hôtel Loews Le Concorde
Loews Le Concorde Hôtel

Québec

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MOT DE BIENVENUE

L'Association aquicole du Canada (A.A.C.) en collaboration avec le Conseil des productions animales du Québec (C.P.A.Q.) est fière de vous inviter à sa 4e assemblée annuelle.

Au fil des ans, l'Assemblée annuelle de l'A.A.C. est devenue, sans aucun doute, l'événement public numéro 1 en aquiculture au Canada. La lecture du programme de cette année vous permettra sûrement de constater que cette 4e assemblée ne fera pas mentir cette réputation.

L'industrie aquicole du Canada est à un tournant de son évolution. Après avoir été particulièrement lente à démarrer, cette industrie, ou plutôt certains de ses segments, commencent à connaître des taux de croissance impressionnants. On peut citer par exemple la croissance vertigineuse que connaît actuellement la salmoniculture marine dans l'Ouest et dans l'Est du pays, ou encore l'élevage de la moule dans l'Est.

Cette croissance importante amène de nouveaux problèmes et de nouveaux défis. Mieux établie qu'auparavant, l'industrie doit maintenant faire face à la compétition et se lancer à la conquête des marchés tant intérieurs qu'extérieurs. Pour ce faire, elle doit d'une part diminuer au maximum ses coûts de production et d'autre part, se lancer à fond dans le marketing.

Le programme des colloques spéciaux que vous propose l'A.A.C. cette année s'inscrit justement dans ce contexte et vise à aider l'industrie et les institutions de recherche et de développement à mieux relever ces nouveaux défis.

En plus des nombreuses conférences techniques régulières et toujours pertinentes, plusieurs conférenciers de marque tant du Canada que de la Norvège, des États-Unis, de la France ou des Îles Britanniques contribueront à rendre cet événement des plus intéressants.

Enfin, il est primordial de souligner que la ville de Québec, hôte de notre assemblée, a été récemment déclarée « Joyau du patrimoine mondial » par l'UNESCO et à ce titre, contribuera certainement à rendre votre séjour à Québec encore plus agéable. Que ce soit du point de vue de l'histoire, de l'architecture, de la gastronomie ou tout simplement de son atmosphère romantique, particulièrement au printemps, la ville de Québec offre au visiteur(euse) une panoplie d'expériences toutes aussi inoubliables qu'enrichissantes.

Au plaisir de vous accueillir à Québec.

Yves Bastien,
Président du comité organisateur
de la 4e assemblée annuelle
de l'A.A.C.

WELCOME

The Aquaculture Association of Canada (AAC) in conjunction with the "Conseil des productions animales du Québec" (C.P.A.Q.) is proud to invite you to its fourth annual meeting.

From year to year, the AAC annual meeting has become, without any doubt, the number one aquaculture public event in Canada. Reading this year's programme will surely convince you that this year's meeting will maintain this reputation.

The evolution of the Canadian aquaculture industry has reached a new turning point. After a quite modest start, this industry or more pricesely certain parts of it are now experiencing very impressive growth. As an example, cage salmon farming is developping very rapidly in Western and Eastern Canada. The mussel growing industry is also progressing fast in Eastern Canada.

This important growth is creating new problems and new challenges. More established than before, the industry must now face the competition and rush to the conquest of both national and international markets. To do so, the industry must, on one hand, reduce its production costs as much as possible and on the other hand, tackle the marketing business.

The topics of the special symposia proposed by the AAC this year have been chosen especially to try to help the Canadian industry as well as R and D institutions meet these new challenges.

In addition to the numerous standard technical sessions that are always relevant, several guest speakers of note from Canada, the U.S.A., Norway, France and the British Isles will contribute to making this year's annual meeting, a very interesting one.

Finally, the fact that Québec City, host of the meeting, has recently been declared: "A world heritage treasure" by UNESCO will surely contribute to appreciably improving the quality of your stay in Québec. Whetter your interest is in history, architecture, gastronomy or more simply in a warm romantic atmosphere, this enchanting city has a multitude of attractive and unforgettable experiences to offer.

Hoping to welcome you to Québec next spring,

Yves Bastien,
President of the Organizing Committee
Fourth AAC Annual Meeting

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SPEAKERS AND COLLABORATORS

WORLD AQUACULTURE AND THE CANADIAN MARKET

Conférencier: D.E. Aiken, Department of Fisheries and Oceans,
Speaker: Biological Sciences Branch, St. Andrews, New Brunswick.

MARKETING OF NORWEGIAN SALMON: RECENT SUCCESS AND FUTURE PROSPECTS

Conférencier: Wollert Krohn-Hansen, ass. Managing Director,
Speaker: Norwegian Fish Farmers Sales Association.

THE MARKETING OF STERILE SALMONID EGGS

Conférencier: Michael Ingram, Managing Director, Clearwater
Speaker: Trout Limited, Kirk Michael, Isle of Man, United Kingdom.

MARKETING-PROMOTION: U.S. TROUT FARMERS ASSOCIATION

Conférencier: Ray Cooper, Executive Director, United States Trout
Speaker: Farmers Association, Little Rock, Arkansas, U.S.A.

LOUISIANA CRAWFISH PRODUCT MARKETING: A "TAIL" OF SUCCESS?

Conférencier: Kenneth J. Roberts, Specialist, Marine Resource
Speaker: Economics, Louisiana Cooperative Extension Service, Louisiana State University.

Collaboratrice: Lynn Dellenbarger, Assistant Professor, Department
Collaborator: of Agricultural Economics, Louisiana State University.

PRODUCTION AND MARKETING HISTORY OF THE PRINCE EDWARD ISLAND BLUE MUSSEL

Conférencier: John Sullivan, Atlantic Mussel Consultants Treasurer,
Speaker: Atlantic Mussel Growers Corporation Limited.

Collaborateur: Raymond MacKean, Managing Director and
Collaborator: Secretary, Atlantic Mussel Growers Corporation Limited.

LES DIFFÉRENTES ORIGINES DE L'EAU UTILISÉE À DES FINS PISCICOLES AU QUÉBEC

Conférencier: Robert Champagne, Secteur agricole, Service des
Speaker: productions animales, Ministère de l'Agriculture, des Pêcheries et de l'Alimentation du Québec.

ATLANTIC MARINE WATER RESOURCES: THEIR UTILIZATION AND POTENTIAL FOR AQUACULTURE

Conférencier: R. H. Cook, Fisheries and Environmental Sciences,
Speaker: Biological Sciences Branch, Scotia-Fundy Region.

Collaborateurs: F. Sander, Biological Station, St. Andrews, New
Collaborators: Brunswick.
R.E. Drinnan, Halifax Fisheries Research Laboratory. Halifax, Nova Scotia.

APPROCHE NUTRITIONNELLE DES PROBLÈMES D'ÉLEVAGE DES SALMONIDES EN EAU FROIDE

Conférencier: S. Kaushik, Laboratoire de nutrition des poissons,
Speaker: I.N.R.A., Station d'hydrobiologie, Saint-Pée sur Nivelle, France.

BREEDING FOR COLD WATER AQUACULTURE

Conférencier: G. W. Friars, Chief Scientist, Atlantic Salmon
Speaker: Federation and Research Associate, University of New Brunswick.

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WORLD AQUACULTURE AND THE CANADIAN MARKET

by D.E. Aiken

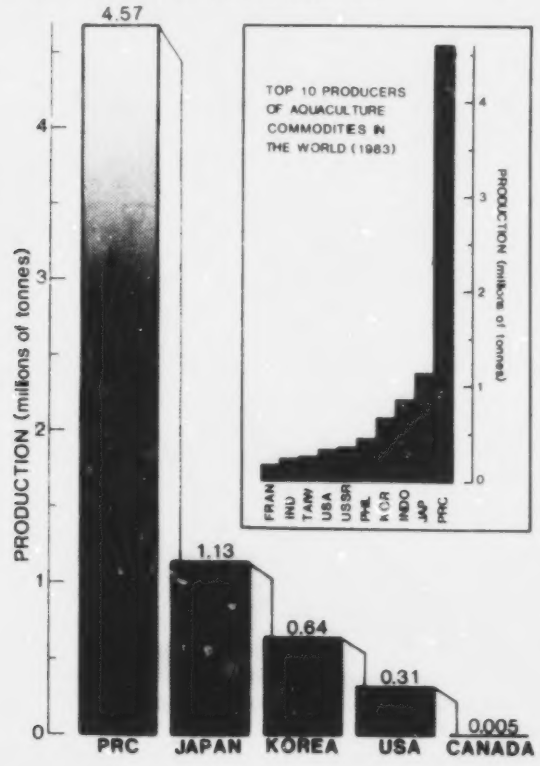
Canada is not a significant force in the world of aquaculture producers. Consider the following statistics:

1. Canadian aquaculture production barely topped 5 thousand tonnes in 1983. In that year the People's Republic of China produced 4.6 **million** metric tonnes.
2. Of the 87 countries listed by FAO as producers of aquaculture commodities, Canada ranked 50th, behind New Zealand and Turkey.
3. Canada records production in only two of the four aquaculture commodity groups, and not much even in those two. China cultivates more species of carp than Canada does all species combined.
4. Nations such as Taiwan and Malaysia produce more than 9000 grams of aquaculture commodities for each of their residents. Canada's per capita production is less than 200 grams.

These facts suggest that changes in Canada's current annual aquaculture production of 6-7 thousand tonnes are unlikely to have much effect on a world industry that produces upwards of 13 **million** tonnes. However, changes that occur in world production or marketing patterns can have a profound influence on the developing Canadian industry. The following sections contain my personal impressions of changes that are taking place in world aquaculture, and the possible impact that these changes may have on the Canadian aquaculture industry.

FIGURE 1:

CANADIAN AQUACULTURE PRODUCTION RELATIVE TO OTHER MAJOR PRODUCERS OF AQUACULTURE PRODUCTS. INSET SHOWS RELATIVE PRODUCTION OF THE TOP TEN AQUACULTURE PRODUCING NATIONS.



TRENDS IN WORLD AQUACULTURE

Aquaculture originated in ancient times as a means of producing animal protein to feed the family and provide something of value that could be bartered for service or other commodities. This is the so-called 'subsistence' level of production, where water farming is but one of several food producing activities undertaken by a family or group of families.

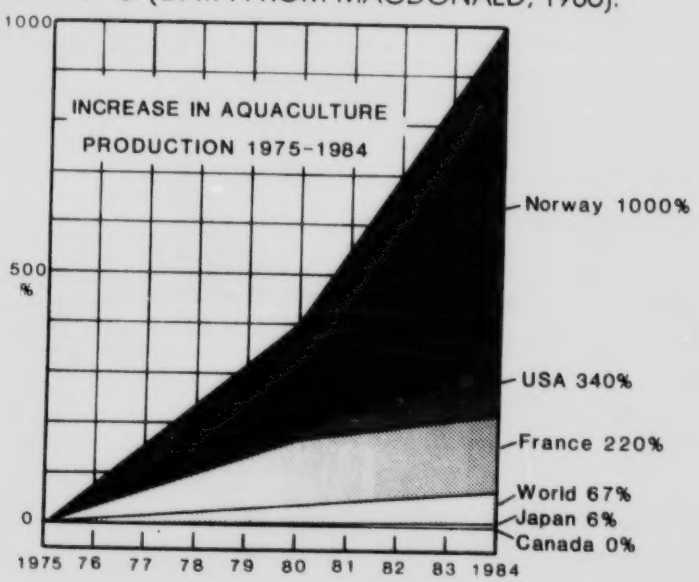
As world population expanded and coalesced into societies with trades and specialties, aquaculture began to shift from subsistence to domestic production. Aquatic farms, like their terrestrial counterparts, became full-time occupations for some individuals, and the production from these farms was distributed through established market channels to consumers throughout the country.

Historically, subsistence and domestic production have concentrated on the lower value finfish such as **Tilapia**, milkfish, and the various carps, and these have provided a much needed source of protein for an expanding and increasingly hungry population. But in recent years the need to generate foreign currency and obtain a favorable trade balance has prompted a shift toward a third type of aquaculture production: export. Export production differs from domestic production in the marketing channels that are employed and — in the developing countries at least — in the types of species produced.

For obvious reasons, aquaculture commodities produced for export tend to be the so-called luxury species that command attractive prices in the developed countries. Salmon, shrimp and oysters are examples, and there has been a world-wide increase in production of these commodities in recent years. In parts of Asia there is concern that the favorable economics of the export sector will displace traditional production for domestic consumption, thus creating a food shortage for local populations. In the Philippines, for example, a quarter of a million hectares of ponds are gradually being converted from milkfish to prawn production.

The farmed salmon industry is also undergoing dramatic change. In 1976, Norway dominated the market with slightly over 1,400 tonnes. That country

FIGURE 2:
INCREASE IN AQUACULTURE PRODUCTION BY SELECTED NATIONS BETWEEN 1975 AND 1984. CANADIAN PRODUCTION REMAINED STABLE DURING THE PERIOD, WHILE WORLD PRODUCTION INCREASED 67%. (DATA FROM MACDONALD, 1986).



now produces 50,000 tonnes, and expects to be marketing close to 100,000 tonnes within three years. Meanwhile Canada, Ireland, Chile, Japan, New Zealand and Scotland are also expanding their production of farmed salmon.

In summary, there is a trend among world producers to shift away from subsistence and domestic production into the export sector, and the popular commodities of the immediate future will be salmon and the penaeid shrimps. Because the export sector allows developing countries ready access to badly needed foreign exchange, and the United States and Japan are leading importers of seafood products, producers in the developing countries can be expected to pursue markets aggressively in these countries.

PROFILE OF CANADIAN AQUACULTURE

Canada is a relative newcomer to aquaculture. In much of the world the motivation for aquaculture development has been the need for animal protein, but Canadians have never suffered from a shortage of animal protein. Beef, pork and poultry have been abundant and relatively inexpensive, and Canada's wild fisheries have been among the world's most productive.

As a result, the incentive for aquaculture development in Canada has been economic, not nutritional. Canadian consumers enjoy a high standard of living and a taste for premium quality seafoods. Aquaculture provided the means to produce high value seafood for an established market, so it was attractive to investors, and investment dollars enabled the developing Canadian industry to adopt advanced technology and concentrate on the cultivation of high value species.

This type of commodity is normally exported, but in Canada the heavy domestic demand for luxury seafoods has absorbed most of what has been produced in the country, and there has been little need to develop export markets.

In 1983 only about 10 per cent of Canadian aquaculture production was exported, and that primarily to the United States. Salmon producers export a larger proportion of their production, but the majority is still sold for domestic consumption. Of the 300 tonnes of Atlantic salmon produced by Bay of Fundy farmers in 1986, only 60-75 tonnes were exported (all to the United States). Seventy five per cent of the production was sold in Canada, but there are concerns that the domestic market may not absorb a greatly expanded quantity of traditional salmon products at established prices.

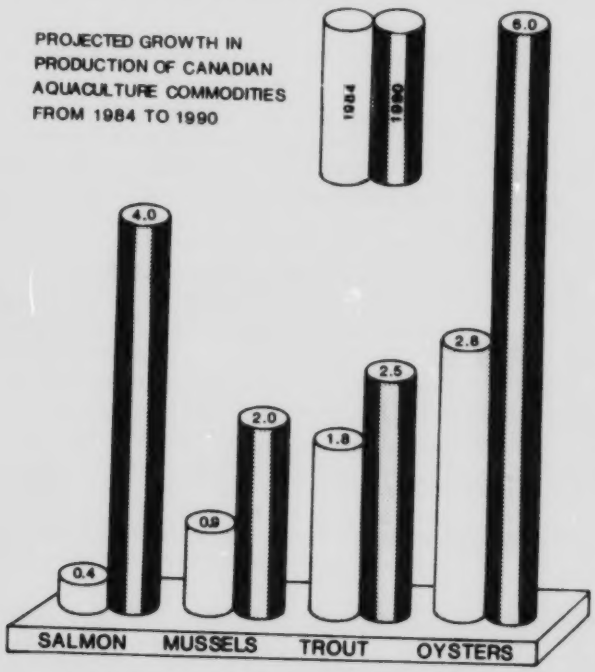
In summary then, Canada's current annual aquaculture production of some 7,000 tonnes of salmonids and molluscs is targeted primarily for domestic consumption, and the minor amount that is committed for export goes almost exclusively to the United States. The three major export candidates are salmon, oysters and mussels, but none has yet established a strong export market.

IMPLICATIONS FOR CANADA

The changes we are seeing in world production and marketing philosophy combined with a rapidly changing supply-demand situation in Canada suggest the Canadian industry is approaching a period of change in its aquaculture marketing opportunities. Up to this point, Canadian growers have been able to find a domestic market for everything they produced, but current projections indicate the domestic market for traditional salmon and mussel products — two of our top aquaculture commodities — will be much softer by 1990. In 1986 the Atlantic salmon farmers produced roughly 300 tonnes. The

1987 production of Atlantic salmon may run as high as 1,500 tonnes! With production of Pacific salmon keeping pace, and total salmon production expected to reach 4,000 tonnes by 1990, there is a good possibility that Canadian salmon growers will soon encounter a changing domestic market situation that may force the industry to adopt lower selling prices, reduced profit margin, a greater variety of products, and an interest in the export market.

FIGURE 3:
PROJECTED INCREASE IN PRODUCTION OF MAJOR CANADIAN AQUACULTURE COMMODITIES BETWEEN 1984 AND 1990. (DATA FROM MACDONALD, 1986).



Developing that export sector will be a major challenge. Competition is intensifying because of the world trend toward production of high value seafoods, and in salmon alone, more than a half dozen countries are expanding their production. Studies suggest that the world market will only be able to absorb 130,000 tonnes of salmon in 1990, and Norway, Scotland and Ireland alone project a production of nearly twice that figure!

The situation is less critical for the molluscan commodities since the domestic market still has some additional capacity, but offshore competitors are already reaching the Canadian consumer with their own products (New Zealand with its green lipped mussel, for example).

A shift from domestic to export production involves more than the scaling-up of production and a willingness to sell. Domestic sales are relatively uncomplicated, and domestic markets can be serviced by small cooperatives or even individual growers. The export market, on the other hand, requires that resources be pooled to meet major commitments, and that marketing expertise be employed for product development and promotion.

The world aquaculture situation is changing in several ways, and it is difficult to predict the ultimate effect on Canadian aquaculture markets and aquaculture producers. The trend toward export production of high value commodities is intensifying competition in the world marketplace, and offshore

competitors may begin displacing Canadian products both in Canada and abroad. On the other hand, intense competition can increase consumer awareness, enhancing worldwide demand for seafood products and expanding the market. There is also an increasing sensitivity to the health aspects of seafood products, and this may also encourage market growth.

On the other hand, the rapidly expanding world salmon farming industry is facing a potential shortage of suitable fish meal for salmon rations, a shortage that is seen by some as critical. If so, it could constrain expansion of the salmon industry and reduce the anticipated production surplus.

Contemporary market projections often underestimate the ability of the private sector to respond to changing market opportunities, and fail to correctly anticipate the effects of multiple variables on the growth of market demand. Therefore, future market prospects may prove more encouraging than they now appear.

However, the world aquaculture situation is changing, and the Canadian industry should be prepared to change with it. Three courses of action seem appropriate:

a) a "tuning" of current production systems to obtain better efficiency in anticipation of reduced profit margin from future operations;
b) an aggressive development of the marketing technology required to exploit export markets for Canadian products; and
c) a diversification of the aquaculture base, both in numbers of species produced and in types of products marketed from each of the cultivated species.

By tuning for more efficient production, developing export markets, and diversifying the commodity base, Canada can adapt to changes in world aquaculture markets and continue growing with this potentially lucrative industry.

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SESSION THÉMATIQUE 1:
Expériences fructueuses en marketing de produits aquicoles.

THEMATIC SESSION 1:
Successful Experiences in the Marketing of Aquaculture products.

MARKETING OF NORWEGIAN SALMON: RECENT SUCCESS, AND FUTURE PROSPECTS

by Wollert Krohn-Hansen

Even though the production of salmon and rainbow trout has reached considerable dimensions in Norway, it is in many ways still a "new" industry. New, not only in terms of age, but also in relation to know-how, research, veterinary services, production of equipment and marketing.

In the year of 1978, when the Norwegian Fish Farmer' Sales Organization was founded, the total production of salmon and trout amounted to 5 600 tons. (All references to tons are in metric tons).

The development from 1980 to 1986 is shown in figure no 1. Today, salmon represents approximately 90% of our total production, and the figures since 1980 are as follows:

1980: 4 153 tons
1981: 8 422 tons
1982: 10 266 tons
1983: 17 016 tons
1984: 22 300 tons
1985: 28 665 tons
1986: 45 675 tons

This development in volume even surpasses the most optimistic estimates, and the export value is approximately US $ 260 000 000.

Even though we experienced a considerable drop in prices in 1986, the industry shows a satisfactory earning power, and it has become a significant factor in the economic life along our coast. The industry enjoys loans and compensations usual for business located in the districts, but it does no receive state subsidies.

Through their organizations, Norwegian fishermen have obtained a sales monopoly protected by Norwegian law. This tradition was adopted by the fish farmers and resulted in the foundation of the Norwegian Fish Farmers' Sales Organization in 1978.

The NFFO is owned by the fish farmers, and it controls first-hand sales of all farmed fish in Norway. Every fishfarmer is a co-owner of the sales organization, with a share in proportion to their production.

There were several reasons for establishing the sales organization. First, we wanted an efficient instrument for keeping good and stable prices. Second, through our influence, we wanted to take part in the making of a future for the industry. At the time, production and sales were not coordinated and consequently, the production was often inadequately planned. The result was a varying supply of fish to the market and subsequent unstable prices.

The sales organization has a monopoly of all sales of farmed fish. This right is protected by the law. The same law says that fish farmers can only sell their products through buyers recognized by the Sales organization.

Formally, the Sales organization may conduct the distribution of the fish as well, but so far we have chosen not to do so. We have come to this conclusion because we believe that others are able to do the job equally well, particulary with the skilled buyers we have today. Also, by entering that sector of the trade, we just might find ourselves heading for collision with our own customers.

Instead of conducting the direct distribution of the fish, we have chosen to emphasize the development of a mutually rewarding collaboration with the buyers we have approved, who today number approximately 70.

After negociations with representatives for the buyers, minimum prices for salmon and trout are stipulated, that is: the lowest price a fish farmer can charge for the fish he delivers. The buyers, by and large whole-sale buyers and exporters, conduct subsequent national and international sales.

The export is taken care of by the 70 buyers, but most of these firms are of a somewhat modest size. From this follows that their financial clout for market influence and marketing is limited indeed. Therefore, instead of competing with the buyers, the NFFO has involved itself strongly in marketing. Our 1987 marketing budget amounts to US $ 3 600 000. Norwegian fish farmers approve of this, having realized that market investments are imperative to obtain acceptable prices later.

The budget is administered by the Marketing Council, a body where both buyers and producers are represented. The Marketing Council plan and carry out national and international market activities, but I will get back to this in a moment.

I would like to draw your attention to one essential aspect of the Sales organization's policy, namely its function as information office. The Sales organization and the fish farmers have a general agreement on major points, such as: sales only through approved buyer, stipulation of minimum prices and some other aspects of the price package.

We deliberately try to avoid further control such as limitations for setting out fish, slaughter control, no options for the producers when choosing buyers of levelling of prices for that matter.

The Sales organization emphasizes information for the fish farmers on market developments. The fishfarmers direct their information at the Sales organization on quantities etc. This mutual exchange of information provides a basis for recommendations given to the fishfarmers.

Every now and then, these recommendations border on "threats", but the absolute condition is that the fish farmer himself makes the decision. It is his responsability that the fish he sets out will turn into a commodity later on.

The fishfarmers realize that the development of the industry is dependent on a first-class product. Only a first-class product will bring a high price and a high price is necessary to make it worthwhile to be involved in fish farming.

Furthermore, the fishfarmers are perfectly aware of the fact that a continual success rests on their capability to supply the markets with fish at all times.

Quality and continuity are a must that the fishfarmers have to face up to.

On the whole, the Norwegian farmed salmon has been exported as fresh. Our most important market has been and is the European countries (60%). Low tariff rates for fresh commodities and an attractive location made the market accessible when the exportation of Norwegian salmon started.

Most of the Norwegian fresh salmon for the European market is being smoked. However, higher tariff rates for smoked salmon make it difficult for us to compete with salmon smoked in Norway. Also, we might easily find ourselves competing with the customers of our own importers.

While looking for new markets in 1981/82, one developed satisfactory containers and packing for air freight of fresh fish. Thus, the American market was available for Norwegian farmed fish. The way the US $ went, plus the shortage of Pacific salmon made the Norwegian export to the USA a very

attractive one in 1983, 84 and 85. In 1986, the Norwegian export of farmed salmon reached an all-time high of 10 200 tons. In comparison, we exported 10 100 tons to France.

As you can see from the figure, Denmark and West Germany are large markets as well. The relatively large Danish volume is explained by Danish re-exportation to other countries.

So far, the Norwegian marketing has been directed at restaurants and hotels rather than the individual consumer. Due to a shortage of fish, the fresh fish market became a very lucrative business indeed.

With the development we can see in the international market for salmon today, it is still possible to increase the volume of fresh fish. We would also have to enter the retail market, but only into that part of this market where a good price is offered for a product of high quality.

Product improvement in the future will bring about new constellations and a change towards bigger units. The system we have today with innumerable participants, is not designed to cope with the rise in turnover which is expected in Norway and elsewhere.

The large number of producers and exporters of salmon in our country, makes it necessary to resort to generic marketing, promoting NORWEGIAN SALMON.

We, who represent the Norwegian fish farming industry feil that we have been fairly successful in our marketing so far, — with great help of a favourable development of the US dollar.

I have been asked to explain the reasons for our success, and in my opinion it boils down to:

* High quality
* Quality control
* Unfailing supply

This is the backbone of our product.

In collaboration with Norwegian authorities we have developed standards of quality control. Our aim is to make the producers realize that we have to do even better that what is required through public regulations.

NORWEGIAN SALMON is to appear as a first-class product which will be attractive for that particular sector of the market that we focus our attention on. The characteristics of the fish must match those of a completely fresh product.

The fish farmers must understand that when it comes to quality, we cannot allow any compromises.

The Sales organization has a handpicked staff whose sole function is to guide and instruct about quality.

Planning and distribution are essential to achieve continuous supply.

By having access to information on the production we are able to supply the markets with fish exactly when the markets are ready for it.

If a customer is unable to anticipate a steady, unfailing supply of Norwegian Salmon, he is likely to go elsewhere to do so.

As I mentionned earlier, the Marketing Council has a budget of US $ 3,6 millions.

In addition to the administration in Norway there are two offices in France and Spain. In the near future, offices will be opened both in the USA and in West Germany.

What about the future?

As most of you may know already, the fish farming industry in Norway is regulated through licences. Last year, we had approximately 500 operative farms. In view of the total number of licences which have been granted, the next few years will see a total production of salmon and trout of approximately 80 000 tons. The world production of farmed salmon will probably be somewhere between 110 and 120 000 tons around 1990.

We believe that there will be a market for that kind of a production, but there will also be great demands on product improvement, distribution and marketing.

From a Norwegian point of view, an expansion of the total market for farmed salmon would be much to be preferred to an increase in our own share in the already existing market.

This ought to inspire salmon producers of all nationalities to cooperate instead of using one's energy on worrying about what other competitors are up to.

Today, the interest in high quality seafood is enormous, and the various nations involved in aquaculture will gradually develop a wide range of products.

The prospective interest in these products will depend on our ability to face up to consumer demands. Appearance, texture and freshness of a high quality product are qualities designed to meet the consumer's demand. And most important of all: the product must be available when the customer is ready to purchase.

In order to meet this challenge, one must have an open mind when working methods are concerned. But in the process, one must take care not to allow any compromises when it comes to the two fundamental standards: quality and continuity.

If we do this right, we will have a product that an increasing number of consumers are willing to pay the right price for.

Thank you for your attention.

THE MARKETING OF STERILE SALMONID EGGS

by Dr Michael Ingram

Since the mid 1970s the production of sterile (triploid) salmonid eggs has moved from the experimental stages to the semi-commercial reality. I say semi-commercial because the transition has not been completed without a number of major problems.

The value of a sterile product has been appreciated for a number of years by many producers who are interested primarily in the production of large fish. To a lesser extent there is the attraction for the restocking market of a fish which can be introduced to a fishery without the risk of any interbreeding with the endemic population.

The ideal situation can be envisaged, in a farming situation, when a 100% sterile stock is grown through to market with the minimum handling. If produced from an initial all-female stock then the divergence of growth associated with mixed sex production is reduced — food is converted for flesh throughout the full cycle (subject to environmental factors) and not diverted to gonad production.

With salmonids in an intensive aquaculture situation, the presence of gravid females requires that they be spawned. If the Company involved is geared logistically to maximum growth to market, the presence of gravid fish (or spawning males) can affect the production economics quite seriously — the damage being dependant upon the percentage grilsing (salmon) or gravid (trout).

The question is posed at an early stage as to "What production units are targets for the marketing of sterile ova or fry?"

The broad answer is this: — Producers of small fish for table production whose company strategy is to market their fish before they reach maturity have no apparent need for the more expensive sterile eggs. I use the work "apparent" for the specific reason that steriles do show a more uniform growth than diploids which might be of economic value.

In the salmon world, if a company has created a market for a fast growing "grilse" then the cost of a sterilization programme may not outweigh the advantages to be gained. This is an arguable point as it is the "choice" of being able to sterilize or not which is the major market attraction of sterilization.

Before discussing further the merits or otherwise of sterile salmonids it is relevant to understand both the techniques involved and their recent commercial history.

It is essential that a sex-reversal programme is initiated at the outset. There is not advantage in a sterile male production as the secondary characteristics remain unchanged. Thus, spawning colouration, flesh quality, aggressive behaviour and **saprolegnia** attacks (in certain countries) remain major economic problems. In any event, the production of all-females must now be considered a standard salmonid production technique (which one hopes does not spread to the human race)!

The triploidy process refers to the techniques necessary to create a third set of chomosomes in the nucleus at a specific stage after fertilization. There are a number of methods by which this process can be induced artificially but the method at present in commercial use is by the initiation of an electro thermal shock at a specific point in the process of cell division.

Under certain specialized conditions whether in the laboratory or in the field, the accuracy of the triploid rate can be as high as 100%.

But a commercial marketing policy must be based on the ability to scale-up a technique to produce consistant results. And it is in this area that the major problems lie.

Since 1976 a number of producers have, at some time or another, marketed sterile (triploid) ova. Very few are still in the marketing arena with any sizeable production. Why?

There are a number of reasons for this decline in production. In the first instance the high mortality which is often a by-product due to lack of temperature control, poor egg quality, uneven egg size etc., can reduce the economic viability to unacceptable levels.

Secondly, the quality of the product can be very variable. Smalleyed ova producing weak embryos are another by-product. The initial slow-growth reports still relate to the situation where steriles are fed in the same environment as their more aggressive diploid counterparts.

The production of mosaics (mixture of chromosome combinations) can lead to huge mortality on hatch — or later at swim up. All the above problems were discovered during the transfer stage from experimental to commercial. And indeed many of those problems are still with us to this day.

The present situation, therefore, is a complex mixture of a buying market which knows the obvious advantages of steriles in the right production programme but is nervous of the quality of production — and rightly so in many cases.

What has proved to be of vital importance in the production of steriles is the quality of the broodstock at source — and thus the egg. Any organism subjected to a sudden double temperature shock is going to suffer unless it is in peak condition and at its optimum strength. Salmonid ova are no different.

A weak egg, a small one, an egg which is treated too long after ovulation, a mixture of different strains, the effect of packaging and travel on eggs which have undergone shock treatment — all must be considered by both the supplier and the supplied. For it is a recognised fact that the commercial production of sterile ova on a large scale is still in its infancy. The rewards at the market end are potentially enormous, therefore some hiccups must be accepted.

One of the first marketing objectives therefore is to alert the buyer to the fact that, while a good supplier is making every effort to send out only the highest quality eggs, the process is so critical that a certain risk factor must be considered acceptable. A continuation of this is the vital element of feedback from the customer regardless of the type of product — how else can perfection be attained?

The sterile marketing programme must therefore be aimed at potential customers who the supplier knows will benefit from the eggs. There is no advantage in selling high priced eggs to a farmer whose strategy is designed for a pre-maturity sale. The ideal marketing objective is to offer the **choice** of sterile or all-female eggs rather than "force-sell" one type only.

A trout farmer might well wish to develop his own marketing policy to large fish over a period of time. In which case an increasing feed input of steriles should be recommended.

Trout fingerling suppliers who plan to transfer their stock to seawater to increase growth rate will benefit enormously from steriles, for both the lack of

mortality due to spawning condition and the reduction in vibriosis, plus the fact that steriles can be transferred into seawater sooner than diploids.

The potential for reduced affinity to disease is very tempting to concentrate on when undertaking the marketing of steriles in today's aquaculture climate. It must however be viewed with caution.

On our own farms we at Clearwater have recorded very significant decreases in outbreaks of vibriosis on sterile stocks compared to control diploids. It is, nonetheless, still too early to state categorically that "steriles are more resistant to disease". It is here that customer feedback is absolutely vital.

What can be hypothesised however is that any stock which has a reasonably uniform growth and requires mininum handling (e.g. for sorting sexes, gravids etc.) must reduce the stress. It is an accepted fact that stress is one of the major contributors to problems of disease and, therefore, any advances in stock management in this area have to be considered advantageous.

The markets for sterile eggs can therefore be targeted with relative ease.

But the problem arises when a potential customer does not necessarily wish to buy-in eggs but would prefer to sterilize them himself. Recent experience has shown that the straight-forward sale of the necessary equipment is not a successful marketing strategy.

While the basic techniques have been well documented, at least in the academic world, the practical application of the technique on any large scale requires 3 major factors:

1. A scientific/biological knowledge
2. A highly efficient spawning technique
3. A constant quality broodstock

Consider the following: — For a regularly consistent supply of high yield triploidy with low mortality and minimal cell disruption there are a number of variables which have to be catered for. These include:

1. Constant temperature control at ALL stages regardless of the volume of eggs.
2. Alterations in time from fertilization to water addition to time in the sterilizing tank subject to strain, egg size, egg quality, milt quality, egg quality.
3. Differential times and temperatures during the electro-thermal shock to accommodate any temperature changes or alterations in timing of egg supply.
4. A constant spawning rhythm to provide a consistent supply of eggs for the process.

On any but the most professional of broodstock production units such variables cannot realistically expect to be adapted for.

Any small diversion can upset the rhythm and the overall triploid rate is consequently reduced — bringing the economic viability down to critical levels.

This argument against the one-off sale of sterilizing units has been more than justified over the past few years. Modern farms are not geared to adapt their own work force to such a highly biotechnological process as high yield sterilization.

The available market remains, therefore, split into three major categories:

1. The farmer who is prepared to settle for 40-50% sterility and possible high mortality by carrying out his own process.
2. The direct sale of pre-sterilized eggs.

3. The sale of sterilizing contracts where specialised companies spawn and sterilize on-site for various companies.

At Clearwater we are happy to supply sex-reversed milt to assist the farmer interested in the first option.

Similarly the sale of eggs is our major production from our disease free farm on the Isle of Man.

The third option presents a number of marketing difficulties. The cost, for example, is bound to be high because a company is taking on a direct top level consultancy operation — with all the equipment and travel expenses accruing. Plus, of course, the "time spent" cost for the evaluation of triploidy and the detection of the critical timings and temperatures per strain.

From the sellers point of view such contracts also pose problems in that a "contract sterilization" deal allows little long term control over the quality of egg and milt production (so essential for successful sterilization). Added to that is the fact that the product is then transferred to the client's hatchery and is again out of the contractor's control.

Nevertheless, it is a proven fact that contracted sterilization not only utilizes the client's own strain of fish but also allows time for the farm personnel to be trained in the many small nuances of the process, so essential to the ultimate success.

Over the past three years the direct egg sale market from our own farm has risen from a sale of 750,000 steriles in 1983 (out of a production of 30 million) to 14,500,000 in the 1986 season. This upper limit has been set by ourselves due to the extra man hours required in the production of steriles. As a matter of interest the rest of our egg production is totally all-female with a few mixed-sex eggs being produced as special favours to certain long standing customers.

Does the market for steriles show any particular trends?

The answer is an emphatic "yes" and points the finger toward a dramatic increase in the demand for larger fish. The UK is at the bottom of the scale in sterile requirements, for trout in particular, while France, Italy and Scandinavia all show a very positive demand. The United States has also shown a strong interest and it leads me to hypothesize that the heavy marketing of salmon is creating a general demand for the larger fish. Whether the production of large trout is any potential competition on the international market is a question which is outside the scope of this discussion, but I would recommend that the relative advantages of lower production costs and current international marketing strategies are studied very closely by interested parties.

In conclusion, I think that it is reasonable to comment that the market for sterile eggs and the technology to sterilize such eggs is very specialised, but not necessarily small. The process has progressed from the experimental stage to the commercial but is still in adolescence — i.e. there are still likely to be a number of irritating rashes and spots. However, with both the suppliers and the buyers aware of this fact and providing each other with a measure of tolerance and feedback then the present aquaculture scene will gain another very powerful weapon in the effort to expand in a commercially successful and environmentally responsible manner.

MARKETING — PROMOTION: U.S. TROUT FARMERS ASSOCIATION

by Ray Cooper

The production and marketing history of the United States Trout Farmers Association is impossible to define, because until now there has been no concentrated effort to promote the consumption of Rainbow trout by the organization. Neither has there been any effort to market Rainbow trout through the USTFA office.

Only in the past year has the association undertaken a program of promotion. Not marketing mind you, but promotion . . . the generic promotion of generic Rainbow trout.

There is no plan, now or in the forseeable future, for the Association to become involved in the actual marketing of trout. There are many reasons for this . . . approximately 160 reasons, in fact. That's the number of active members currently on the rolls of the United State Trout Farmers Association. All are individuals and all are going about the business of marketing trout in their own way. They seldom confide in one another and have made no attempt, as far as I know, to involve anyone outside the company in their marketing plans. Most, in fact, have no plan . . . other than to sell all the trout they can produce.

There are exceptions to this, of course. A few large producers/processors hire advertising agencies to assist with marketing and plans, but this is the exception rather than the rule.

Consequently, the Association will continue to confine its efforts and activities to promotion.

The present activities include point of purchase materials, recipe pads, a cookbook, regular mailings to food writers and editors, participation in varlous promotion activities, such as the American Seafood Challenge, seafood exhibitions and promotional efforts of the Gulf & South Atlantic Fisheries Development Foundation and the West Coast Fisheries Development Foundation. And, one of our most successful efforts has been the National Rainbow Trout Cooking Contest, which generates approximately 1,000 entries annually from almost every state.

The objectives of the USTFA trout promotion effort is to promote the consumption of trout produced for food and to promote interest in pay-to-fish operations which feature trout.

The clientele, then, are those interested in catching their own fish and those who would purchase trout in retail establishments and those who would order trout in food service establishments.

One of the most important lessons to be learned in salesmanship is that "... your best prospect is the person you have just sold!" That holds true for trout, also. The best prospect for the sale of trout is someone who has eaten . . . and enjoyed . . . trout. Or someone who has fished for, and caught, trout at a pay-to-fish operation.

With point of purchase materials, we have attempted to reach shoppers on the retail level. They may intend to purchase fish for a meal, but they may not have decided which fish to purchase. Perhaps point of purchase advertising will bring them around to trout. It appears to be working, is about all I can say about this approach.

We have not yet undertaken point of purchase advertising for food service establishments . . . for example, table tents and menu additions. These

will come in the near future. There is one additional activity which we feel will be important in our overall promotion program: Video. We are working on a 30 minute video of the entire trout industry in the United States. It will be available for showing by any member of the USTFA and every effort will be made to show it before groups of retailers, food service personnel and anyone else who expresses any interest. The video is being shot and edited on three-quarter, broadcast quality tape, just in case we might find a spot for it on television.

Another video, featuring a chef preparing four simple trout dishes has been shot and is being edited. It, along with pads of printed trout recipes (Trout Recipes Made Simple!) will be made available to home economists through the United States Department of Agriculture.

This program came about because I contacted the leadership of my state's home economics program with the idea of developing a trout cooking contest for youngsters. The leadership was interested; however, they explained that many of the home economists didn't know how to cook trout, so how could they be expected to teach and participate in any time competition? I thought that was a rather good point. So, I went back with a proposal to make the home economists more aware of trout and how easy it is to prepare by using a video tape, backed up with the printed recipes. (By the way... the printed recipes are the same as those we use in point of purchase material for retail operations.)

While marketing strategies and structures are formulated by the various trout processing firms to suit their individual needs, and while the United States Trout Farmers Association has no processing or production departments, we will assist individual firms whenever it is possible and when that effort presents no conflict of interest.

LOUISIANA CRAWFISH PRODUCT MARKETING A "TAIL" OF SUCCESS.

by Kenneth J. Roberts and Lynn Dellenbarger

BACKGROUND

The freshwater crawfish is referred to as crayfish, crawdad, mud bug, or a host of local names. There 100 plus species found within the United States. These two elements can cause confusion when new customers are sought in non-traditional markets. The species dominant in the U. S. are **Procambarus clarkii** and **Procambarus acutus acutus**. In marketing the former are referred to as red swamp crawfish and the latter as white river crawfish.

The first reported commercial crawfish catch statistics date to 1880. Though this original report documented only 23,400 pounds, recent production from natural habitat can reach 20 million pounds. Additionally large, more reliable supplies have been available for the past fifteen years. Although pound culture of crawfish began around 1950, it took twenty years for acreage to reach approximately 24,000. Farmers in 1986 had increased acreage to 125,000. Concommittant with the massive increase in acreage has been higher average yields due to improved cultural practices. Total supply of Louisiana crawfish exceeds 70 million pounds at this time. The states of Texas, South Carolina, Arkansas, Florida, and Mississippi have crawfish farming industries contributing production from approximately 15,000 acres. Louisiana based on natural and farmed sources of supply controls 90 percent of the market.

PRODUCTION AND MARKETING HISTORY

An element fundamental to an accurate understanding of crawfish aquaculture and marketing in Louisiana is the market information system. Essentially, it is non-existant! There are no data that have been historically collected on the production acreage and associated yields. This is an impediment to both an accurate understanding of supply and an effectively structured marketing program. A series of estimates of acreage devoted to crawfish farming in ponds is presented in Table 1. There are several gaps in the 1960-86 estimation period. These exist simply because no agency or expert devoted time to make estimates. In fact, most of the estimates reflect different individuals using non-standardized procedures. Neither the government of Louisiana nor the United States include crawfish acreage and yield in official statistical series. Crawfish yields seem to be viewed by some agencies as an agricultural matter and by others a fisheries matter. The result is an unsatisfactory depiction of supply and price. The seasonal nature of supply is consequently not documented well enough to inform prospective buyers. In such situations, a buyer's best market information system is that which evolves through purchases overtime with various suppliers. It is, therefore, of no surprise that buyers new to the crawfish market proceed cautiously with small orders.

Crawfish are harvested daily from November to June. Farmers use baited traps at the recommended density of 20 per acre. The natural habitat catch begins in March. Crawfish are placed in plastic mesh sacks while on board the harvest boat. These sacks of 40-45 pounds are delivered to buyers daily. Cool, humid storage is necessary at this stage to maximize shell life. The market cycle of harvest to consumption should occur within four days for live marketed product. A historical perspective of market development must be secured from an evaluation of the acreage growth cited in (Table 1). The 1971 to 86 entries in the table are the most reliable. During this period acreage grew at an annualized rate of 11.6 percent. Total supply to market would double every four years after allowance for yield gains per acre. This fact alone signifies the

stress placed on the marketing system. The orientation of wholesalers to provide crawfish in live form to essentially only a Louisiana market compounded smooth functioning of the market.

As supply dramatically increased in the 1970's, local markets would be easily jammed with live product. The situation was described in an economic report in the following way.

> As supplies begin to increase, the plant owners and dealers become so busy buying, selling, and managing, they have little time to try to solicit new customers and expand the market area. All of the dealers and plant owners trying to sell their crawfish in a concentrated market area cause prices to fall. (Hudson, 1970)

Processing plant investment accelerated as more businesses were formed and existing firms expanded to achieve value-added processing. With existing live resale markets frequently stressed investment in processing technology to cook, peel and package crawfish meat was necessary. The number of crawfish processing plants licensed by Louisiana increased from approximately 35 in 1970 to 90 in 1986. During this evolution from a primarily live product reaching consumers to multi-product offerings, processing became more capital intensive yet markets remained local in nature.

TABLE 1:

CRAWFISH FARM ACREAGE 1960-1986

Year	Acreage	Year	Acreage
1960	2,000	1978	60,000
1966	6,000	1981	70,000
1968	10,000	1982	90,000
1969	12,000	1983	100,000
1970	18,000	1984	105,000
1971	24,000	1985	115,000
1973	44,000	1986	125,000
1975	45,000		

Initial insight to utilization of crawfish came in 1974. The survey of processing companies documented a marketing pattern of few crawfish products of increasing volume pressed into a limited geographic area. Only three states other than Louisiana were receiving crawfish products. Six cities in Texas, Mississippi, and Kansas reflect the limited success of individual firms in achieving market diversification. Twenty-five cities in Louisiana received crawfish from the processors. The combined local and out-of-state buyers used 70 percent of supply at the retail sales level and the remainder reached consumers via restaurant purchases. The dependence on retail sales at specialty seafood stores and supermarkets indicated at that time the limited processing capabilities.

> For many of the processors, the peeling operation is a salvage activity engaged in to avoid losses on live crawfish that cannot be readily sold. (Carroll and Blades, 1974).

This philosophy discouraged investment in processing and marketing procedures that may have matched the rising productive abilities of the farming sector. Among the processing companies all were single unit operations each with limited financial, management, and marketing capabilities. Mergers and acquisitions were not used to pool resources. This was due in part to the limited geographic farm area a plant could effectively serve. The end result was an industry in the early 1970's marketing 65 percent of its product in live, raw form. Thirty-five percent of raw material was processed into meat

with the viewpoint of a salvage operation. Salvaged product consequently could not be afforded much management and financial resources to effectively market.

RECENT PROCESSING/MARKETING DEVELOPMENTS

The mid-70's signify an effort to develop processing procedures which capitalize on emerging market opportunities. Research results pointed to the potential for increased sales in restaurants.

> . . . the chance of introducing the live product in restaurants or seafood markets successfully in out-of-state markets seems to be limited. (Carroll and Blades, 1974)
>
> Initial attempts to test market crawfish in markets outside Louisiana should concentrate upon restaurants, perhaps the larger-better known restaurants in major cities. (Carroll and Blades, 1974)

The focus would be on cooked, peeled and deveined crawfish meat. This effort proved to be necessary but also premature.

The economic structure of the crawfish industry, in part, limited success. Entry into large scale restaurant markets out-of-state would not occur for another decade. Crawfish harvesting and processing occurred in a structure which reacted to supply instability and product inconsistency. On initiation of the new market approach of the mid-70's crawfish supply was primarily tied to fishing natural habitats. The lower uncertainty of production from ponds slowly lessened year to year supply variation. However, the prevalence of natural habitat supplies providing 50-70 percent of total supply made taking an early position in the market too risky. With natural habitat supplies crowded into the March-May period the processing companies could not effectively market the November to May pond supply. Buyers could withhold major purchases until the inevitable lower supply prices. The industry structure consisted of single owner operated processing companies. No collective, cooperative action developed which would smooth marketing problems. Pooling of product to meet large buyer needs for consistent quality and year-round sales was not possible. The market remained current. This meant numerous small sales with little inventorying by processors to lessen pressure on prices. A maturing of processor philosophy was necessary to overcome this structural matter.

Processing technology remained a constraint to better marketing. The structure of large numbers of processing companies, each with small shares of overall supply, operated by owner operators restricted standardization and technological improvements. Mechanization of the peeling procedure was sought to increase product quality and significantly reduce costs. Hand labor had been used to pick the cooked whole crawfish. With six pounds of live crawfish yielding approximately one pound of meat, and the compensation of picking labor at $.60 per pound, the market price must be high. Several machines were developed without major success. One company utilized a peeling machine which required alteration of the processing procedure. The normal full cook procedure had to be shortened to a quick blanch in order for the mechanical picker to be efficient. Though efficient from an engineering standpoint the brief heat treatment failed to impart the traditional red color to the dorsal meat surface. Visually the product was a harder sell in local markets. A second problem of the short, low temperature procedure of mechanization was the failure to deactivate enzymes in the meat. This resulted in an inferior texture often even producing mushy meat when used by buyers. Focus on the mechanization of processing quickly faded. At this time no mechanical procedure of meat removal exists. Workers pick by hand at the current time for the piece rate of $1.00 per pound.

The processing techniques had been oriented to providing fresh cooked crawfish meat to local buyers. These buyers were using meat with what the layman terms fat covering the product. The fat, actually the hepatopancreas, comprises on average eight percent of the finished product weight. The instability of the fat seldom became a marketing problem until off-season and new markets were developing. Rancidity occurs with fat-on product at an unacceptable frequency. Frozen meat also occasionally takes on a bluish color resulting from oxidation due to improper freezing. Dipping meat in a .5 to 1 percent citric acid solution has evolved as a satisfactory processing procedure. Discolored product sometimes reaching the consumer and incidences of rancid fat from frozen product added to other marketing problems:

a) seasonality,
b) lack of consumer knowledge about crawfish,
c) price instability.

The processing companies responded to the above matters with significant resources provided by university researchers. Components of the program to improve crawfish products include plant design, proper cook time determination, product stabilization, freezing techniques, quality control programs, and packaging improvements. A comprehensive study of the processing industry in 1983 yielded insight to the status of the processing/marketing companies. The processing plants averaged 5,200 square feet with five year round full-time employees and four seasonal employees paid on a wage basis (Dellenbarger, et al, 1986). Signifying the importance of value added processing, the plants averaged 27 crawfish meat pickers paid on a piece rate basis. Markets in 35 states and four countries were identified. This dramatic change from the market identification in a previous study was significant from another perspective. Eight crawfish product forms were reaching market needs of varied buyers. Tabulating crawfish product sales figures revealed that approximately 62 percent of sales were of meat products. The product categories achieving the best performance in out-of-state markets were frozen meat, purged live, frozen whole raw, frozen whole cooked, and prepared entrees. In fact, among these only the frozen meat category had more in-state sales than out-of-state. These are conservative estimates of success in market diversification because the data reflect only the first buyers' location. Many first buyers are local wholesalers and distributors who resell in turn out-of-state.

A 1985 survey of 236 U.S. seafood distributors revealed that 23 percent currently sell crawfish products. This is an impressive figure when compared to the early 1970's. Large markets remain to be entered but both prospective buyers and Louisiana processors are aware of impediments. Processors cited lack of quality control and undesired sizes of crawfish supplied to the plants as critical factors. At the time of the survey, there were no specific quality standards established by the industry for the purpose of enhancing sales. Concerns included the absence of size categories for whole crawfish and meat along with guidelines of acceptable fat levels. Seafood wholesalers perceive problems associated with profitable crawfish marketing to include lack of consumer awareness and unfamiliarity with sources of crawfish products. Among twelve possible responses offered seafood wholesalers, these two were specified in 70 percent of the responses. These prospective buyers recommended menu clip-ons, in-store tests, advertising art, and information for employees as the high priority needs to help sell crawfish.

The situation in Louisiana as indicated by comparison of early and recent studies points to more successful marketing out-of-state with a wider variety of crawfish products. A large percentage increase in U.S. seafood consumption certainly played a role in successfully marketing ever increasing crawfish supplies.

INDUSTRY ORGANIZES TO EXPAND MARKETS

Several noteworthy efforts to structure the crawfish processing/marketing industry to capitalize on the trend to seafood took place within the last four years. Restructuring of program efforts was the approach of an industry trade group. The other changes involved the creation of new trade structures. In the former case, the staid Louisiana Crawfish Farmers Association embarked on an effort to promote increased crawfish consumption. This was achieved by developing the International Crawfish Tasting and Trade Show. Through this vehicle the general public's awareness of crawfish as food products was addressed. Each show has progressed toward more interaction between processors and other sellers of crawfish products and prospective buyers worldwide. A special day is designated during the show whereby only invited sellers and buyers meet to discuss business prospects. Thus, crawfish farmers have become activists in the market development of their products. Perhaps this development indicates a maturity of the crawfish farming industry reflective of marketing actions taken by U.S. traditional food commodity growers. The crawfish farmers have not organized an effort to differentiate pond raised crawfish from natural supplies during this foray into the field of marketing. This is in contrast to our region's other aquacultured crop, catfish. While there may be a basis for differentiation between pond and wild catfish, no foundation exists on which to build separate markets for the two sources of crawfish.

Three major new structures were developed after 1982. They involve processors, farmers and the public sector. The structures are noteworthy alone, but are significant for other reasons. First, they identify a cooperative philosophy both within sectors and between sectors. Secondly, it requires leadership to organize the structures and successfully bring them to operation.

The first structure was a new association structure called the Associated Crawfish Processors of Louisiana. Members strive to unify the Louisiana crawfish processors into an effective organization which will advance the industry and act in the interest of the individual processor. Specific activities deal with out-of-state marketing, establishment of standards to provide customers quality products, and achieve technological advances.

Secondly, a Louisiana Crawfish Promotion and Research Board was created by action of the legislature. The purpose of the 1983 act is to provide a voluntary method of raising revenues to be used for developing markets for Louisiana crawfish and funding research which will increase production of Louisiana crawfish. All segments of the industry from farmer to marketer are represented on the ten member governing board. Funding is provided through assessments on bait for crawfish traps and sacks used in marketing. These farmer level inputs give foundation to the argument that this is a producer financed effort to increase markets. To date a number of board activities have effectively addressed the need for printed material to aid in product introductions and consumer education.

The 1985 Louisiana legislature responded to a missed market opportunity for the industry by establishing the Louisiana Crawfish Market Development Authority. A major upscale restaurant sought 700,000 pounds of crawfish tail meat washed free of fat. Several independent processors pooled efforts to meet the order but failed to provide over half the contracted amount. To meet standards of the buyer, the processors had to contract with a food packaging company in another state to receive the raw material and do the final packaging. This first access to large national markets proved to be less than ideal for both contract participants. Through quick action the legislature found that:

1. The present scattered locations and difficulty of access to out-of-state and export markets constitute an economic burden on the state of Louisiana.

2. The general lack of modern crawfish packaging, warehousing, distribution and marketing facilities within the state which can serve large out-of-state markets on a continuing basis contributes to the poor economic condition of all segments of the crawfish industry and the lack of adequate capital available within the industry to correct this situation contributes significantly to this poor economic condition within the industry.
3. The development of a modern, consolidated wholesale crawfish packaging, warehousing, distribution and marketing facility in Louisiana would be in the best interests of the people of this state and such facility would coordinate satisfactorily with domestic and international marketing programs being developed by the Louisiana Department of Agriculture and would otherwise facilitate the sale of Louisiana crawfish and crawfish products.
4. Sufficient revenues can be derived from the development of a modern, consolidated wholesale crawfish packaging, warehousing, distribution and marketing facility located in Louisiana to amortize the costs thereof within a reasonable period of time and it is fitting and proper that the costs of developing such a facility should be defrayed insofar as practicable by notes or certificate of indebtedness payable from the revenues to be derived from the construction and operation of such facility.

The result has been progress toward a centralized processing, packaging, and inventorying facility. In 1986, the approximate 20 processor members of the corporation which emerged from the Authority's actions operated from a rented facility. In 1987, the corporation, Louisiana Crawfish Wholesalers, Inc. (LCW), built a large centralized processing facility. Equally important is the state of Louisiana's participation in arranging for up to $3 million in operating capital. This financial backing is essential for success with a seasonal product with a high unit inventory cost. LCW in the process of organizing for large institutional sales has identified new processing techniques and advances in packaging from which all sectors will benefit.

SUMMARY

A processing industry of barely twenty years experience has been through massive changes. These changes include the market choking effects of a highly seasonal raw material distributed to essentially a local market by numerous small firms unable to differentiate their product. Progress occurred in processing technology to increase the marketability of crawfish in new markets. Companies become larger through diversification into non-crawfish products and developing additional crawfish products. An awareness of the value of cooperation in solving industry-wide problems signaled a maturity which resulted in leadership developing new marketing structures. These structures included farmers doing something about marketing rather than simply complaining about prices. Legislative action signaled new approaches by creating a self-funded industry marketing board and a market develop authority serving to facilitate large scale sales. University support with farming, processing, and marketing research findings provided the technical advancements for a progressive industry. The Louisiana Cooperative Extension Service authorized the publication of a directory listing crawfish processing companies, identifying their products, citing the key contact person, etc. This directory now in its second edition provides an effective means of uniformly responding to inquiries received by the various industry structures.

While the movement to a larger more geographically diverse market has not been smooth, it has been successful. Farmers using aquatic procedures to produce and market food must be cognizant of a key similarity to agriculture. Research findings leading to better technology and inputs may forever yield to short run supply increases at a pace which the market cannot accept

at stable prices. The successes the crawfish marketing activities in Louisiana produce may not arise through higher prices but in more subtle ways. Among these are briefer periods of extremely low prices, a narrowing of the intra-seasonal high and low prices, and more volume with less negative producer price impacts. Aquaculture's productive capabilities will continually stress the skills of individual marketing companies and require innovative structural changes of industry participants.

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PRODUCTION AND MARKETING HISTORY OF THE PRINCE EDWARD ISLAND BLUE MUSSEL

by John Sullivan and Raymond MacKean

INTRODUCTION

The following presentation represents the views and opinions of the author. The main purpose of the presentation is to encourage aquaculture development in Canada and in order to do so, I will share with you some of our experiences. I anticipate that in relaying some of the events surrounding our successes, failures, trials and tribulations, that it will be possible to perceive some of the problems that have been solved, others that are being addressed, and yet others that need tending.

Please keep in mind that everything we did was new and untested. We were developing a completely new resource, and although we all had our little dreams of where it might lead us, none of us could see very far ahead to consider all the stumbling blocks.

HISTORY

In the beginning, we were really naive. I can clearly remember some first informal meetings with some people from government. I don't believe I was the only one to come away with the idea that all we had to do was hang out some lines in the water, wait for a couple of years, and then hire a man or two to help us carry the money to the bank. The biggest question seemed to be what colour Cadillac we should order.

A Belgian tobacco farmer by the name of Joe Van Den Bremt is considered the Granddaddy of the cultured mussel industry on Prince Edward Island. Sometime around 1975 our Provincial Department of Fisheries read the published experiences of Ed Meyers of Abandoned Farms in Maine; saw the huge volume of blue mussels being consumed in Europe and the great mounds of that same shellfish growing along our shores and they began to put two and two together. By 1978, they were in deep discussions with Joe Van Den Bremt, who was quite familiar with the European scene and had been doing his own thinking about growing mussels in this country. And so it began. One experiment and test followed another, until in 1980, it was clear it could be done — cultured mussels could be grown here.

1980 was the year when most of us got into it. By that fall, Joe Van Den Bremt had shown that cultured mussels could be grown in commercial quantities, and, somehow, we were led to believe that there would be a market for them.

As I said, we were naive in those days. If anyone was questioning the existence of a market they were not saying it out loud. I believe it was around that time that the Market Development Centre on P.E.I. stated that we may expect to sell three to four thousand pounds a week — tops. But instead of that figure causing us to examine the whole idea more closely, it only added to the rush to stake-out claims for water leases. People who had no serious intention of growing mussels applied for water rights thinking they could make a quick capital gain from it. It could be that some others scented some free Government money coming out of it, especially as the whole thing was considered something of a part-time, almost casual occupation that would help fill-in the season for lobster fishermen.

It gradually dawned on us that growing mussels was only the first step and we did not really pay much attention when the word "processing" came

up in discussions. I'm sure some of us had the idea that "processing" simply meant picking them over and packing them by hand. So that when it was announced that construction of a processing plant would start immediately our enthusiasm knew no bounds.

It took something like six months for our water lease applications to find their way through a system that was, and still is, designed to accommodate the oyster industry. But in the Spring of 1981 we got the green light and the Provincial Government sweetened the pot by offering the loan of 1000 styrofoam buoys with a forgiveness of 25% of the capital cost if we paid it all off within two years. (Interest was charged at the rate of 16.5% per annum).

That offer is a good example of the understanding of realities existing at the time. We were told it takes two years to grow mussels, but here was Fisheries somehow imagining that crops could be instantly turned into cash the moment they were ready to harvest.

With many of us embarked on our first growing season and thinking of the riches to come, we were quickly brought down to earth by the petition for bankruptcy by the firm constructing the first mussel processing plant. Not only were there 18 or so of us with crops in the water with no clear way to sell them when they were to be harvested the next year but the bankrupt firm had gone out to Montreal and Toronto with some pretty strong promises of supply and service that it could not now keep.

That is when our company really got its start. That is when twelve growers banded together under the name of Atlantic Mussel Growers Co-operative Limited to find some way of marketing the crop that was growing in the water.

The Co-op route was not fully understood but one big attraction was that we could form a limited share capital company under that act for only $30. It also implied a group effort that we felt would give strong clout in our representations to both the Provincial and Federal governments for any help we might need.

And we certainly needed all the support we could muster, Even though the Provincial Department of Fisheries had sparked the whole idea of a cultured mussel industry we soon found that their support was more moral than monetary. As for Federal Fisheries all we got for a longtime was blistered knuckles from knocking down their doors and being sent from one office to another.

I believe I should point out here that all this took place before the St. Andrew's Conference which, as you know, saw the birth of the Aquaculture Association of Canada. Back in the days, when we were knocking on doors, little or no notice was being given the fact that Canada was at the very bottom of the list of countries in aquaculture development. The word was known but there was nothing in place to look after it.

What that meant was that any Fisheries & Oceans person showing sympathy or interest in our cause would quickly find himself saddled with the whole can of worms on top of any other duties that he was required to handle. Little wonder that we got shunted from one to the next right down to the janitor. Of course, we were not so understanding at the time and our tempers got very short.

The excuse we heard was that there were already seventeen licenced fish plants on P.E.I., all of them operating far below capacity and there was no way that they would licence yet another. But their regulations clearly stated that no fish could be shipped out of province unless it was through a properly licenced, inspected plant.

After going to many of there fish plants and finding that none of the would handle mussels unless, of course, government would be willing to put in the equipment and guarantee against losses — we finally obtained grudging permission to use a small building at Beach Point, P.E.I. as a processing facility. This was quickly followed by long recitals from various government departments on all the things we could, and could not do, among which was the need to lay an underwater pipeline 1200 feet out so that we might have a supply of water considered pure enough to meet quality standards.

I will not bore you with the details of the barriers we had to overcome. Let it be enough to say that we would never have got going if it had not been for the co-operative spirit. In our group of twelve growers was a plumber, an accountant, a contractor, an electrician, former bank manager, scuba diver, fishermen and other skills that became cheerfully pooled without any thought of payment for services, and all in the aim of organizing a processing plant so that we could get our coming crops to market. It was only a temporary licence, conditional on better location and equipment once we had chance to see if it would work. But it was all the chance we needed.

With a plant in the making, we now had to find customers for our product. I can tell you that was not easy. We chose Montreal as a first target because, one, it was the closest large city to us, and, two, its population was probably better acquainted with mussels than in Toronto.

That first fall in 1982, I personally tramped from one Montreal fish distribution to another and quickly discovered that it was not just a matter of taking down orders. I don't believe there was anyone who did not say that they would prefer to buy a Canadian product — but, they had already been promised great things by P.E.I. suppliers and government people but nothing came of it. How could we really expect them to cut away from their suppliers in Maine on the basis of our promises now? They also wanted to be assured of a continuous supply the whole twelve months of the year. And then there was always the question that we would be able to deliver orders as agreed, or even if we would be around long enough to warrant their salesmen going out and devoting time to build a demand for our high quality.

In September of that year we managed to lease a 3-ton truck of questionable vintage, but within our budget, and one of our growers would leave every Sunday morning at 7 o'clock, so that by driving all day and night he would be ready to unload at our customer's doors very early Monday morning. He did that every week without fail all September, October, November, and into December — more often than not with loads that were much less than the cost of the trip. Then, all of a sudden, our customers seemed to get the idea "Hey"! These people mean business. They keep their promises.

Now I don't mean to leave you with the impression that it has been all clear sailing since that time. It hasn't. No one, other than our members, will ever know what we went throught to keep it rolling. Everything we did was a new experience that required experimentation and testing and we paid heavily for any wrong guesses. I could tell you of problems that would bring big tears down your cheek, but the point I wish to make is that you must be prepared to withstand a long period during which your customers test the quality of both your product and your service. If both are acceptable you may then experience a gradually increasing sales volume that will withstand the hard knocks and pressures inherent in the fish business. I mean to say by that, that we are at the mercy of Mother Nature. There are going to be times when crops are late to mature, hit by unexpected problems, or just plain impossible to harvest when needed. It is not realistic to think these things may not happen. But if, and when, they do happen, you will badly need the trust and understanding of your customers. They may accept that such problems do arise from time to time, but the important thing is that they know you are doing everything you can to serve them. That trust does not come overnight.

Another thing is fairness and honesty in your dealings. I could say this is really another aspect of the trust I just mentioned. By this I mean that you cannot, for example, try to snap up an account by giving a discount when you have customers in the general area at a higher rate. You can, of course, but the results may be pretty devastating and the opposite from what you planned. The same applies to any exclusiveness of territory. In short, you make a deal and stick to it.

Speaking about territorial selling rights, our experience with this at Atlantic Mussel Growers has not been good. Sometimes it is the only way to go but I would suggest that you give any such proposal long and careful study before jumping, certainly, you should place time limits on the arrangement or tie it to volume goals.

For the most part we have tried to work through fish distributors — people who will have refrigerated storage, delivery, and a sales staff which then can go out, not only to sell our product on a person to person basis, but who will service what they sell. As a general rule we avoid brokers. Of course, there are many, very good brokers, and we happen to have one of these who does an excellent job of selling, service and pays up promptly. My point is, don't jump into such an arrangement without proper investigation.

As for marketing strategy, I think we have gone the full route. I told you about tramping the streets in our first year, and it is not such a bad thing to do. Some of those original contacts are still with us, and treasured.

We have also taken booths at trade shows and handed out samples by the ton. But we would find if difficult to point to any important accounts obtained in this way. We can certainly point to a couple of bad ones though. In the early days we had to try everything but I would have to say that trade shows are primarily a good way to introduce your product into an area, get people to learn its qualities and trust that they will request it when they are buying. That would lead to a distributor connection after awhile, but we found the results of these shows are not in keeping with the high costs of that program. I also think that they are being overdone these days — there are too many of them. We were invited to participate in six of them in mid-February alone.

The Department of Regional Industrial Expansion has an export development program that will advance about 50% of the costs of two trade shows outside of Canada each year. I place emphasis on the word "advance" because it is really an interest free loan repayable on the basis of the business eventually accomplished in the area during the next three years. And when you see the reports involved you may wonder about the interest free part of it.

It is very hard sometimes to actually pinpoint how you get a sales connection, but I do not think it is any exaggeration to say that ours have mostly come from referrals — which really goes right back to what I said awhile ago in remarking on the need for quality and service. One happy customer brings another.

Actually, as far as the mussel business is concerned, I believe we are entering a time when we are not going to be looking for customers. I think we are going to have them pounding on our door and we won't have enough to sell them. If you think I am saying that just to get a laugh out of you, you might consider this:

1) The population of Europe is not so different than the North American total but in Europe the sales of mussels are nearly one billion pounds compared to less than 50 million of every kind and variety here.
2) Processed mussel meat products are literally exploding in all market places and it is reasonable to assume that this must diminish the supply of high quality fresh product available.

3) The National Mussel Marketing Association has been recently formed in the USA to promote consumption of mussels by increasing consumer demand. Private sector members are from many countries. Memberships are also held by various national and international government agencies.
4) The prohibitive cost of clams reflects the declining supply and offers an opening in the marketplace for cultured mussels which are free of sand, grit, and pearls.
5) The bulk of American production comes from Maine. Their bottom-culturing methods are generating environmental and other complaints and there is some quiet question that the present production can be expanded, or even maintained.
6) The West Coast production, both Canadian and American, is infinitesimal and is unlikely to grow because of unique problems that defy solutions.

So, that leaves us in the Atlantic Provinces and Quebec as eventually emerging as the major suppliers to what can only be seen as a mind-boggling market potential.

Now, we have a huge coastline and practically no water pollution problem so you will immediately think that there are limitless opportunities to grow this blue mussel. But do we? Take another look at how much coastline is suitable to that use. You will find that very little has the proper depth, the protection from ice and storms, a natural mussel population, or food production potential. I know in P.E.I. it is already difficult to find good water area to lease.

I will leave it to you to contemplate the rest of it. We happen to think it is all very exciting for the future.

I would be irresponsible if I did not offer a word of caution to those contemplating culturing mussels. Your investment will not only require a large amount of funds and a great deal of energy but be aware that a little knowledge may be a dangerous thing. This is a risky venture which requires research into site selection, spat collection, sock-filling technique, growing, and harvest technology. Before you grow mussels in large quantities, you should know the quality of product your site will yield. Remember the marketplace will only pay premium prices for high quality product.

SESSION THÉMATIQUE 2:
L'aquiculture en eau froide:
problèmes et solutions.

THEMATIC SESSION 2:
Cold-Water Aquaculture:
Problems and Solutions.

AQUICULTURE EN EAU FROIDE: INTRODUCTION DE LA SESSION

par Lars Hansen

Toutes les espèces animales aquatiques élevées par l'homme sont poïkilothermes. Leur taux métabolique est directement associé à la température de l'eau dans laquelle ils se trouvent. La croissance des espèces d'élevage est donc dépendante de la température de l'eau: plus l'eau est froide plus lente est la croissance, le contraire est également vrai. Une croissance rapide est souvent associée à une productivité élevée. Lorsqu'on consulte les statistiques internationales on constate cet état de fait. La culture des espèces en eau froide (des salmonidés et des moules) représente seulement une faible portion de la production mondiale. Même si les pays où on pratique ces élevages sont très avancés techniquement.

L'est du Canada est particulièrement affecté par un climat rigoureux. Les vents dominants et les courants marins contribuent à former un environnement froid sur la côte est du Canada. Dans l'hémisphère nord, au sud du cercle arctique, on peut trouver des conditions semblables dans la mer de Bering et à la mer d'Okhatsk. Aucun autre endroit n'offre de conditions aussi froides au sud. Je me souviens m'être promené en plein hiver dans les rues de Bodo en Norvège (68° lat.) vêtu seulement d'un gilet et d'avoir voyagé dans un traversier sur une mer sans glace dont les eaux n'étaient pas inférieures à 3 ou 4°C. Cette ville est située dans le cercle Arctique à une distance supérieure à 2200 km plus au nord de la ville de Québec. Bodo est à la même latitude que l'île de Baffin.

La relation négative entre l'eau froide et la production aquicole est bien démontrée dans les provinces de l'est du Canada. Cette situation est véridique malgré notre compétence et la présence de vastes côtes. Il en résulte que Québec est l'endroit tout désigné pour discuter des problèmes d'eau froide. Nous devons nous poser des questions sur ce sujet: Quelles sont les ressources d'eau salée et douce? Quelles sont les problèmes créés par notre environnement? Est-ce qu'on peut apporter des solutions à ces problèmes par la technologie, la biotechnologie et la nutrition? Dans cette session nous discuterons de ces questions et nous essaierons d'apporter quelques réponses.

COLD WATER AQUACULTURE: SESSION INTRODUCTION

par Lars Hansen

All aquatic species reared by man are poïkilotherms. That is to say their metabolic rate is directly related to the ambient water temperature. Therefore the growth of cultured species is predominantly controlled by water temperature. The colder the temperature the slower the growth, conversely the warmer the water the faster the growth. Faster growth rates can be associated with greater over all productivity. A demonstration of this increased productivity can be seen in world aquaculture production statistics. The culture of cold water species (salmonids and mussels) represent only a small percentage of total world aquaculture production. This is in spite that northern temperate countries are generally among the worlds most productive and technologically advanced.

Eastern Canada is particularly effected by adverse climatic conditions. Prevailing winds, major ocean currents all combine to make our east cost one of harshest marine environments in the inhabited world. If we compare our winter water temperatures with the rest of the northern hemisphere, the only marine water below the arctic circle which compare are the Bering Sea and the Sea of Okhotsk. No where else are there such extreme winter conditions as far south. For example, I remember walking the streets of Bodo Norway (68° lat.) in mid february with just a sports coat and travelling by ferry over 3 or 4°C ice free water. This is above the Arctic Circle and over 2200 km north of Quebec city, approximately the same latitude as Baffin Island.

The negative relationship between cold water temperatures and aquacultural production is well demonstrated in atlantic Canada. This is true in spite of our expertise and our extensive coastlines. Bearing this in mind Quebec City becomes a logical site to discuss the problems of cold water. The questions one has to ask are: what are the potentials of our marine and fresh water resources for aquacultural production? What are the problems our unique environment creates? Can we find solutions to some of our problems through modern technology and the sciences of nutrition and the new biotechnologies? This session intends to address these questions and hopefully offer some answers.

LES DIFFÉRENTES ORIGINES DE L'EAU UTILISÉE À DES FINS PISCICOLES AU QUÉBEC

par Robert Champagne

INTRODUCTION

L'élevage piscicole au Canada et au Québec est une activité qui est plus que centenaire. La famille des salmonidés est celle sur laquelle l'activité piscicole s'est spécialisée, soit l'élevage de l'omble de Fontaine (salvelinus fontinalis) et du saumon Atlantique (salmo salar) que l'on retrouve dans le milieu naturel ainsi que la truite arc-en-ciel (salmo gairneri). Le but de l'activité aquicole est depuis le début, le repeuplement du milieu naturel. Toutefois, depuis la dernière décennie, l'objectif de l'aquiculture se tourne graduellement vers la production de denrées alimentaires. Cela a amené les pisciculteurs à modifier leurs pratiques et à améliorer la productivité de leur station en cherchant à raccourcir le cycle de production. Ainsi, dans le choix du site de production, on recherche une eau plus chaude l'hiver afin d'optimiser la croissance des poissons qui est fonction de la température du milieu.

LES DIFFÉRENTES SOURCES D'APPROVISIONNEMENT EN EAU DES STATIONS PISCICOLES

Nous pouvons distinguer deux grandes origines de l'eau douce utilisée à des fins piscicoles soit celle de surface et les eaux souterraines. Pour la première, nous pouvons distinguer: l'eau des grandes rivières, les cours d'eau et les lacs.

L'eau des grandes rivières

Elles sont très rares les stations piscicoles qui utilisent l'eau des grandes rivières au Québec. Les raisons de cette non-utilisation sont dues à des températures de l'eau souvent supérieures à 20°C durant l'été et à la diminution de la qualité chimique de l'eau causée par la pollution.

De plus, le régime hydrologique des rivières au Québec est très variable d'une saison à l'autre. En effet, nos rivières subissent des crues très prononcées et des étiages très sévères. Les mois d'avril, mai et juin totalisent en moyenne 47% du ruissellement total annuel. (Tableau 1) Les crues provoquent un transport important de sédiments et les étiages dans les zones à fortes activités industrielles et agricoles s'accompagnent d'une baisse de la qualité de l'eau.

TABLEAU 1:

RÉPARTITION MENSUELLE DE L'ÉCOULEMENT (réf. 1)

Mois	%	Mois	%
Avril	13	Octobre	6
Mai	20	Novembre	7
Juin	14	Décembre	6
Juillet	8	Janvier	5
Août	6	Février	4
Septembre	5	Mars	6

Les cours d'eau

Les cours d'eau sont des canaux d'écoulement ayant un bassin de drainage d'une superficie beaucoup plus faible, généralement inférieure à 50 km². Ils ne traversent que peu de lacs, et ils ont un apport en eau provenant

autant du ruissellement de surface que de l'écoulement sous-terrain. Ces tributaires offrent généralement un régime hydrologique moins variable que les rivières et ils présentent des conditions de température d'eau pouvant se situer entre 0 et 16°C. De plus, il est plus facile de trouver des cours d'eau exempts de problèmes de pollution car ils sont généralement situés dans la partie amont du bassin versant, dans des secteurs à activité industrielle et agricole réduite.

Ce type d'approvisionnement en eau est utilisé à des fins piscicoles et contribue certainement pour une part importante de la production québécoise. Toutefois, en périodes de crues, une intensité élevée de sédiments transportés par l'eau favorise l'apparition de maladies non infectieuses provoquant une altération du système respiratoire des poissons. Cela est le principal problème relié à l'utilisation de cette eau.

Les lacs

Le nombre de lac sur le territoire québécois est très élevé et cela représente un volume d'eau très important. Certains ont des superficies de plus de 1000 kilomètres carrés et des profondeurs pouvant atteindre les 180 mètres. Cependant, les lacs utilisés à des fins piscicoles sont moins grands, les débits à l'exutoire sont d'environ 3000 m³/h et leurs profondeurs dépassent les 30 mètres. Les points importants à considérer vis-à-vis ce type d'approvisionnement en eau sont:

1. Il faut sélectionner un lac ayant une stratification thermique qui permet d'offrir en profondeur des températures d'eau de plus de 3°C l'hiver et supérieures l'été de 10°C en surface. De plus, le volume d'eau sous la thermocline doit être suffisant pour fournir un apport d'eau continuel durant tout l'hiver à cette température supérieure à 3°C.
2. Les systèmes d'approvisionnement d'eau sur lac sont conçus généralement pour des débits très élevés (plus de 1000 m³/h.) Cela implique donc que l'eau doit être acheminée gravitairement à la station, c'est-à-dire, qu'il doit exister un site en aval du lac permettant l'installation d'unités d'élevage à un niveau inférieur à celui du lac.
3. L'implantation d'une prise d'eau lacustre représente un investissement considérable qui est généralement à plus de 300,000,00$. Seule une production de niveau industrielle nécessitant un débit élevé justifie un tel investissement.

Actuellement, quelques stations piscicoles privées et la majorité des stations piscicoles gouvernementales (M.L.C.P.) utilisent ce type d'approvisionnement en eau. Les avantages pour la production sont le maintien, l'hiver, d'une eau dont les températures se situent près de 3 ou 4°C l'hiver et ajustables l'été selon le besoin. De plus l'eau lacustre a beaucoup moins de turbidité que celle des rivières ou des cours d'eau.

Les eaux souterraines

Une majorité des stations piscicoles au Québec utilisent l'eau de provenance souterraine pour leur production. Les avantages de l'eau souterraine pour l'aquaculture sont:

1. Une température d'eau plus chaude l'hiver se situant entre 5 à 8°C qui est propice aux activités d'incubation, qui facilite l'apprentissage des poissons à l'alimentation et qui permet une croissance de ceux-ci.
2. Une absence du risque de la présence de germes pathogènes dans l'eau qui permet la mise en place de stations piscicoles pouvant être accréditées exemptes de maladies.
3. Une température d'eau qui est plus froide l'été.

Le volume d'eau que recèle le sous-sol Québécois est huit fois supérieur à celui des eaux de surface (réf. 1). Cela est vraiment surprenant surtout lorsqu'on regarde une carte du Québec avec ses milliers de lacs et rivières. Cependant une très grande dispersion de cette eau sur le territoire et la présence de dépôts peu perméables ne permettent pas l'exploitation de débits aussi élevés comme pour les eaux de surface. Ces réserves en eau sont maintenues par des précipitations annuelles assez abondantes qui selon les régions varient de 800 à 1500 mm. Seule la fraction de cette eau qui s'infiltre peut être exploitée. Cette eau se distribue dans le sol dans deux milieux différents, soit le substrat rocheux et les dépôts meubles qui le recouvrent.

Dans le substrat rocheux, les débits qu'il est possible d'exploiter sont généralement faibles (annexe 1, tableau 2).

TABLEAU 2:
DÉBITS D'EAU DANS LE SUBSTRAT ROCHEUX (réf. 1)

Perméabilité	Débits observés
faible	<2,7 m³/h
moyenne	2,7 à 8,0 m³/h
élevée	plus de 8,0 m³/h et jusqu'à 100 m³/h occasionnellement

Quelques stations piscicoles ont des puits forés dans le substrat rocheux, ceux-ci en plus de n'offrir que de faibles débits ont généralement une hauteur de pompage qui est élevée. Toutefois ces débits peuvent fournir un apport intéressant dans la section d'incubation et d'alevinage d'une station piscicole. Généralement la température de cette eau est constante durant toute l'année et au sud de la province elle est plus élevée durant l'hiver que la température de l'eau de source (réf. 5, annexe 3).

Les aquifères les plus intéressants sont situés dans les dépôts meubles qui recouvrent le substrat rocheux où il est possible d'avoir des débits d'environ 200 à 300m³/h. Les sites propices au captage de tels débits se caractérisent par la présence dans les dépôts meubles de matériaux granulaires ayant une perméabilité élevée, soit les sables et les graviers. Le débit disponible dans cette formation est fonction de son étendue, de son épaisseur et de son taux de recharge. À cause d'une trop grande dispersion de ces formations sur le territoire il n'y a pas de compilation cartographique à l'échelle du Québec nous informant de leur localisation. Toutefois pour des besoins d'approvisionnement en eau potable, de nombreuses analyses hydrogéologiques ont été réalisées dans des secteurs précis. Également les grandes formations morainiques sont localisées sur le territoire du Québec (annexe 2).

La température moyenne annuelle de l'eau souterraine se situe entre les limites de 4 à 9°C selon la latitude (annexe 3). De plus des écarts de 3 à 12°C sont observés selon les saisons en fonction de la profondeur du puisement ou de la proximité de recharge des eaux de surface; cela est de plus proportionnel à l'effort de pompage. Le territoire du Québec intéressant à la prospection d'eau souterraine est situé au sud du parallèle 50, car plus au nord il y a la présence de pergélisol sporadique où l'eau souterraine a une température près du point de congélation.

Nous distinguons deux modes d'approvisionnement d'eau souterraine, soit celles à écoulement gravitaire (les sources) et les puits pompés. Les dépôts morainiques tels les eskers génèrent des sources ayant des débits élevés de l'ordre 200 à 500 m³/h. On retrouve de telles sources au Québec, principalement en Abitibi. Dans cette région, la température de l'eau des sources est de 5 à 6°C au point d'émergence durant toute l'année. Afin de profiter

d'une eau plus chaude durant l'été, il est nécessaire de la faire passer dans un étang de réchauffement avant son utilisation.

L'eau souterraine captée à partir d'un puits et avec un système de pompage offre aussi un apport intéressant aux stations piscicoles au Québec. Les débits exploités sur ces sites varient de 30 à 250 m³/h. Ceux ayant les plus forts niveaux d'exploitation sont aménagés avec deux ou trois puits dont les débits sont d'environ de 100 à 150 m³/h chacun. Un élément très important pour l'exploitation d'un puits à **débit élevé** est la hauteur de pompage; cette dernière ne devrait pas dépasser 30 mètres afin que les coûts d'exploitation ne soient pas trop élevés. Nous estimons les coûts annuels de pompage à environ 45,00$ par m³/h d'eau pompée, ainsi à titre d'exemple le coût annuel pour l'exploitation d'un puits à cette profondeur de 100 m³/h est de 4500,00$.

L'IMPORTANCE DE LA TEMPÉRATURE DE L'EAU EN AQUACULTURE

La température de l'eau influence le développement et la croissance des poissons depuis l'oeuf jusqu'à la taille adulte.

La période de reproduction et d'alevinage

Le temps de reproduction de l'omble de fontaine et du saumon atlantique est à l'automne, soit au début de la saison froide. Dans le milieu naturel, l'incubation des oeufs de poissons dure généralement tout l'hiver et l'éclosion a lieu tôt au printemps lorsque l'eau commence à se réchauffer. En production piscicole intensive, les processus d'incubation et d'alevinage sont accélérés par le maintien d'une eau plus chaude l'hiver. Ainsi, pour des oeufs d'omble de fontaine, le temps d'incubation est estimé à 120 jours dans une eau à 4°C, tandis qu'il sera de 70 jours dans une eau à 7°C (réf. 6, annexe 4). Par la suite, si la température est augmentée graduellement jusqu'à 10°C durant la période où les alevins sont vésiculés, cette période est alors réduite et le début de l'alimentation des poissons sera plus tôt, soit possiblement en janvier comparativement à la mi-mars dans des conditions d'une eau de source ayant une température de 5°C.

Nous estimons le coût annuel de chauffage de l'eau en utilisant l'énergie électrique à 25.00$ par litre/min. pour chaque degré centigrade d'augmentation de température. Le tableau 4 présente les coûts de chauffage d'eau pour un débit de 50 litres/min. qui est habituellement utilisé pour une production d'environ 100,000 alevins.

TABLEAU 3:

COÛTS DE CHAUFFAGE DE L'EAU SUR UNE PÉRIODE DE QUATRE MOIS POUR LA MAINTENIR À UNE TEMPÉRATURE DE 10°C

Origine de l'eau	Augmentation de la température (°C)	Coût $
Cours d'eau (1°C)	9	3750.00
Lac (4°C)	6	2500.00
Source (5°C)	5	2080.00
Puits (7°C)	3	1250.00

Les coûts de chauffage de l'eau pour la période de reproduction et d'alevinage ne sont donc pas très élevés et ils ne représentent qu'environ 1 à 2% du coût production. De plus, le taux de survie des alevins au passage de la période critique du début de l'alimentation est de beaucoup supérieur dans une eau chauffée à une température de 10°C. Cependant avant d'utiliser de l'eau chauffée il est important de la traiter pour rétablir l'équi-

libre des pressions partielles des gaz entre l'air et l'eau afin de prévenir ainsi une sursaturation en azote.

La période de croissance

À la section 1, nous avons mentionné qu'il y a quatre types d'approvisionnement en eau utilisés dans les stations piscicoles. Une représentation graphique des températures moyennes mensuelles de ces quatre types d'approvisionnement en eau est présentée à l'annexe 5. Dans ces exemples, il est important de remarquer que la température de l'eau de source atteint 12°C l'été due à son passage dans un étang de réchauffement et celle provenant d'un puits est constante toute l'année à 7°C.

Les annexes 6 à 10 sont des représentations graphiques de la croissance simulée de l'omble de fontaine, de la truite arc-en-ciel et du saumon de l'Atlantique dans les conditions de températures présentées ci-haut. Les courbes de croissance sont établies à partir de modèles mathématiques qui sont assujettis d'un coefficient dont la valeur est déterminée avec des résultats réels (réf. 2 et 3).

A) L'omble de fontaine

L'omble de fontaine se reproduit en automne, et selon les conditions thermiques de l'eau en période d'incubation et d'alevinage, il sera possible de produire des alevins ayant un même poids à des périodes différentes au printemps suivant. En effet, les représentations graphiques de la croissance de l'omble de fontaine (annexe 6 et 7) tiennent compte de cette possibilité par la présence de lots à départ hâtifs ayant un poids de 1 gramme à la fin mars plutôt qu'à la fin mai dans la seconde simulation. Nous constatons que le poids de 250 grammes est atteint un mois plus tôt pour le lot hâtif, soit vers la fin mai. De plus selon les quatre types d'approvisionnement en eau, seule l'eau de surface provenant des cours d'eau présente une croissance plus faible, soit un retard de 2 mois.

Il est donc possible d'avoir une différence pouvant atteindre 3 mois de la durée de croissance pour obtenir des poissons ayant un poids de 250 grammes. Cette différence est importante surtout dans le contexte de commercialisation de l'omble de fontaine que l'on vend à une taille portion le plus tôt possible au printemps et jusqu'à la fin du mois d'août. À ce moment, les signes de la maturation sexuelle se manifestent chez cette espèce et il ne devient pas recommandable de vendre des poissons durant cette période. La possibilité de vendre à la taille requise le plus tôt possible favorise une rotation accrue des inventaires de poissons impliquant une production supérieure de la station piscicole. De plus, afin de favoriser un étalement de la production annuelle, il est possible d'avoir des alevins à départs tardifs en utilisant de l'eau ayant une température plus froide durant la période juvénile.

B) Le saumon de l'Atlantique

L'objectif dans la production du saumon est d'avoir des saumoneaux de 1 an+ ayant un poids le plus élevé possible. Tout comme pour la production de l'omble de fontaine, il est possible pour le saumon de l'Atlantique de modifier les conditions thermiques de l'eau utilisée en période d'incubation et d'alevinage afin d'obtenir des lots de poissons dont le développement au début est accéléré. La production de lots hâtifs offre des avantages, ainsi selon les courbes de croissance présentées aux annexes 8 et 9, les lots à départ hâtifs ont un poids de 40 grammes à la fin de mai soit environ 10 grammes de plus que l'autre groupe. De plus, la courbe de température de l'eau de lac offre les meilleures croissances, soit une différence de 10 grammes à la même date sur les autres. Cela est attribuable à une température élevée de l'eau l'été soit 15°C (qui est souhaitable pour le saumon) et à une eau relativement chaude l'hiver de 4°C.

C) La truite arc-en-ciel

À la période de reproduction de printemps de la truite arc-en-ciel il n'est pas possible d'augmenter davantage la température de l'eau pour activer la période d'incubation et d'alevinage; le réchauffement naturel de l'eau intervient généralement à ce moment. Selon les courbes de croissances (annexe 10), on constate une différence significative sur le temps de production selon le type d'approvisionnement en eau, ainsi on observe une augmentation de plus de 8 mois avec un approvisionnement par eau de surface soit les cours d'eau. Dans ces conditions, la truite arc-en-ciel traverse deux périodes hivernales avec une croissance nulle. Donc il est important pour cette espèce de bénéficier d'une eau plus chaude l'hiver pour avoir un cycle de production plus court.

De plus, les autres éléments à signaler qui sont influencés par la température de l'eau sont:

— Une eau trop chaude, soit supérieure à 16°C affectera la santé des ombles de fontaine et l'efficacité de production sera plus faible. Cela équivaut également pour le saumon et la truite arc-en-ciel pour des températures supérieures à 20°C.

— Une eau trop froide l'hiver, soit à 0°C a une incidence sur la mortalité de la truite arc-en-ciel et de plus certains parasites du milieu associés à l'eau froide font leur apparition et ils affectent une population de poissons déjà dans une situation stressante. Cela équivaut également pour l'omble de fontaine mais à un degré moindre.

CONCLUSION

Ainsi la température de l'eau a une incidence sur la production piscicole afin de permettre:

— l'étalement de la production annuelle principalement pour l'omble de fontaine, ce qui favorise une utilisation plus efficace des installations piscicoles

— la production de saumoneaux de 1 an+ ayant un poids élevé

— la production de truites arc-en-ciel (printemps) dans une période de temps acceptable

— le maintien d'un milieu aqueux propice à l'existence des poissons

L'eau dont la température est la plus élevée possible durant l'hiver permet un potentiel de production plus intéressant. Ainsi dans nos conditions climatiques le potentiel hydrique à prévilégier est l'eau souterraine. Malgré une connaissance limitée de cette ressource nous croyons que ce potentiel est limité au Québec. De plus en vertu de l'intérêt public, l'alimentation en eau potable en est la première utilisatrice dans les secteurs à forte densité de population. Dans ce contexte, le développement de la production piscicole devra se réaliser en utilisant davantage l'eau de surface. Cela devra être associé à un développement technologique sur le chauffage de l'eau et la récupération des énergies thermiques industrielles perdues.

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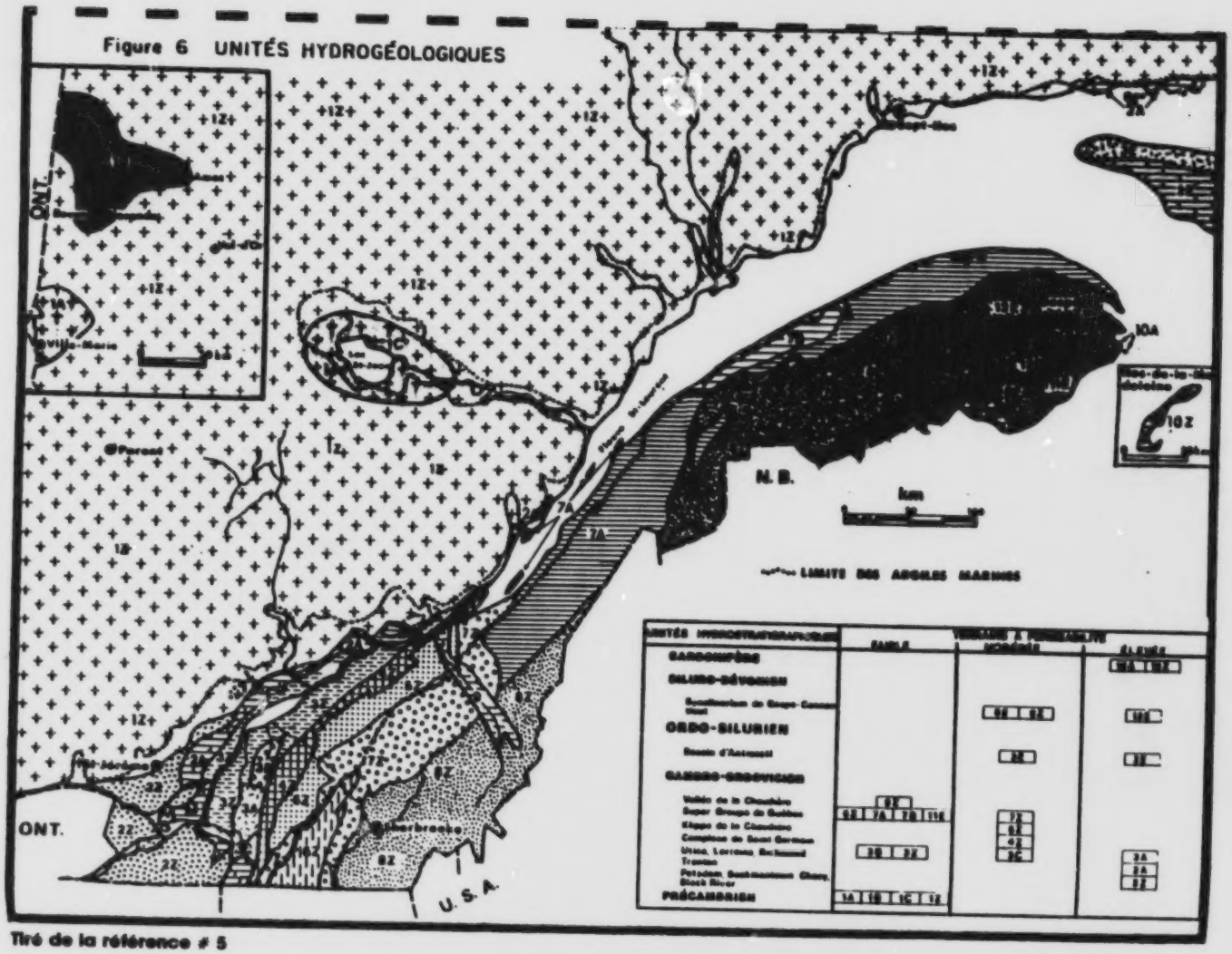
Figure 6 UNITÉS HYDROGÉOLOGIQUES



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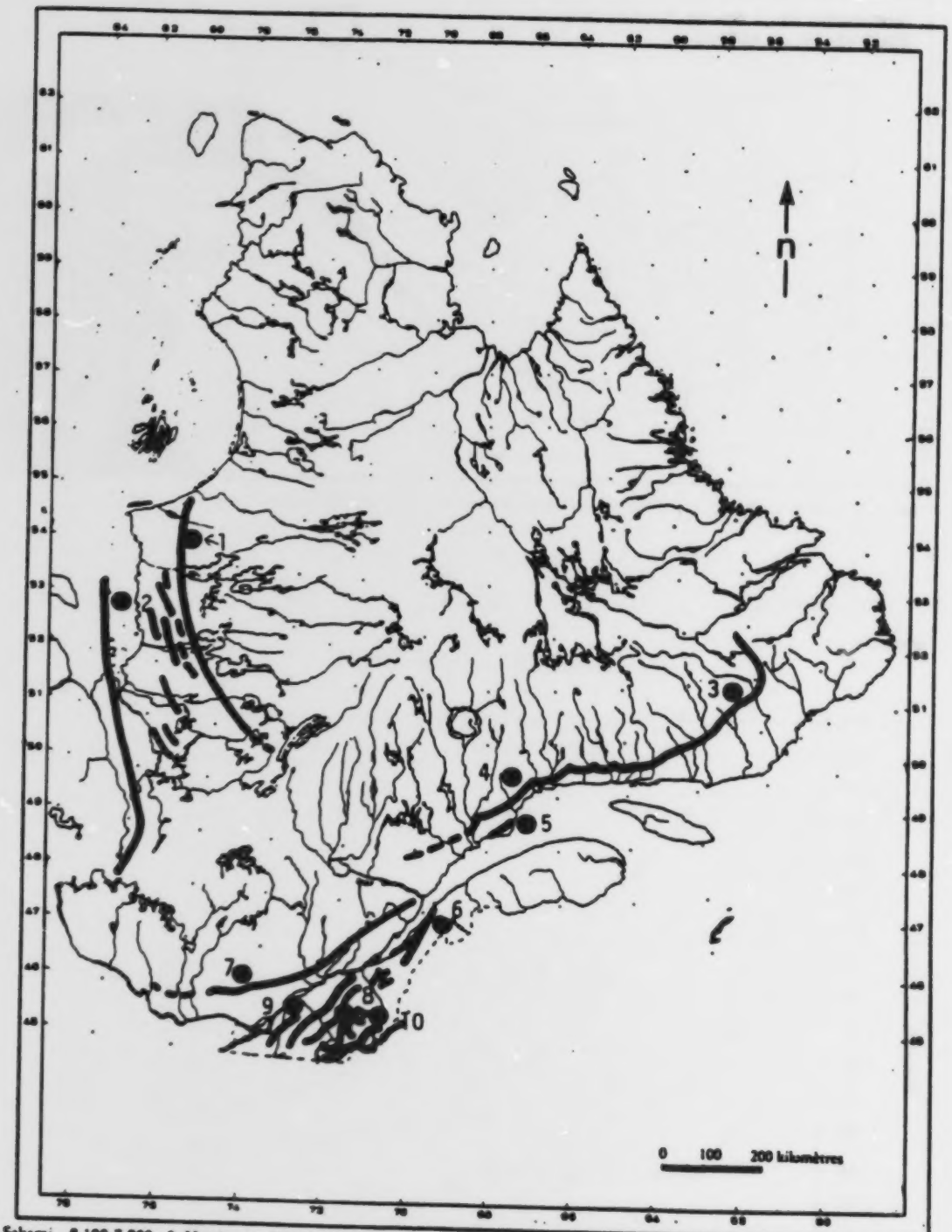
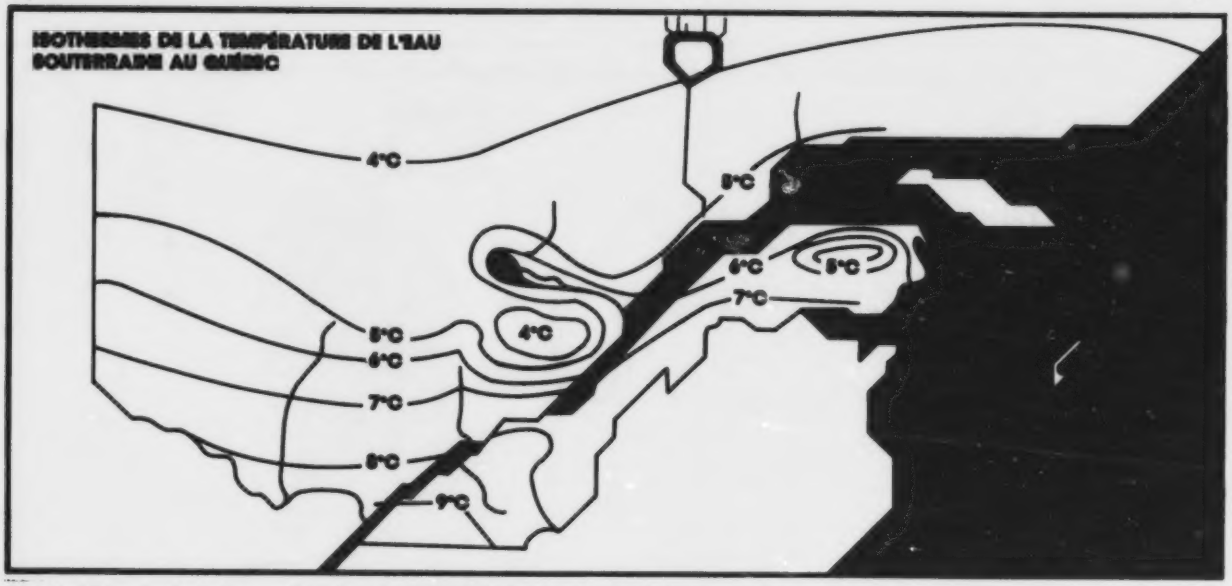


Sakami 8 100-7 900 ; 2. Harricana 9 500-8 000 ; 3. Manicouagan-Manicouagan; 4. Aguanus-Kenamu 9 700-9 500; 5. Baie-Trinité; 6. Sain
manon 13 000-12 800 ; 7. Saint-Narcisse 11 200-10 800 ; 8. Hautes Terres 12 300-12 100; 9. Drummondville; 10. Cascons de l'E
comprend plusieurs tronçons).

Tiré de la référence # 1

ANNEXE 3



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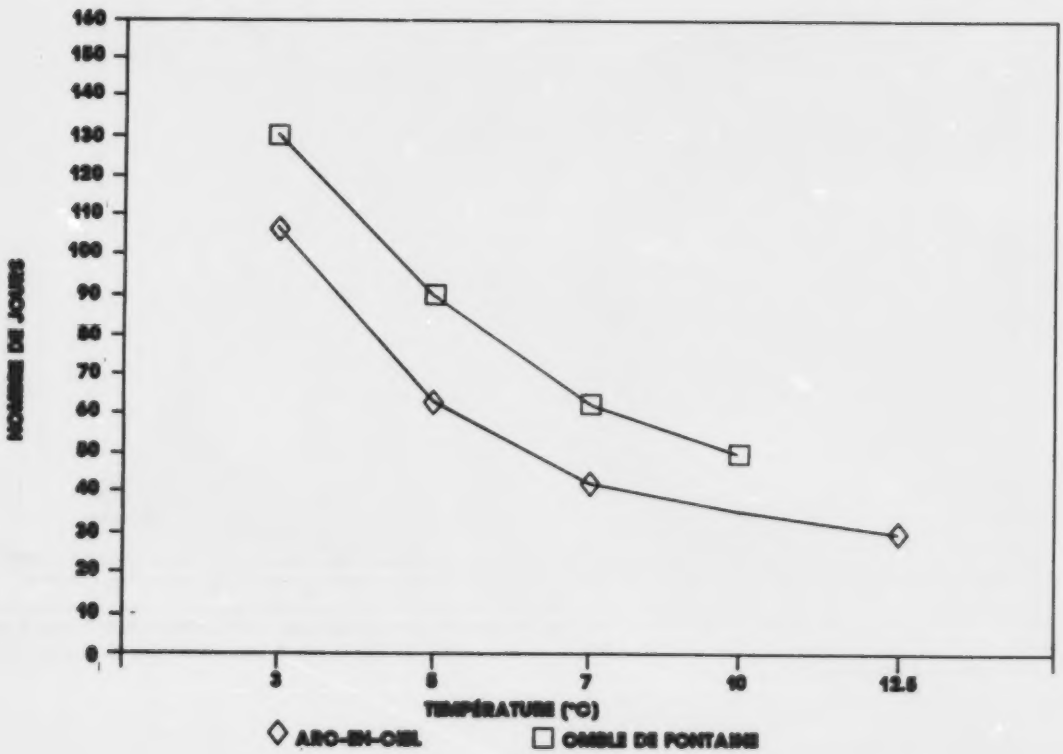
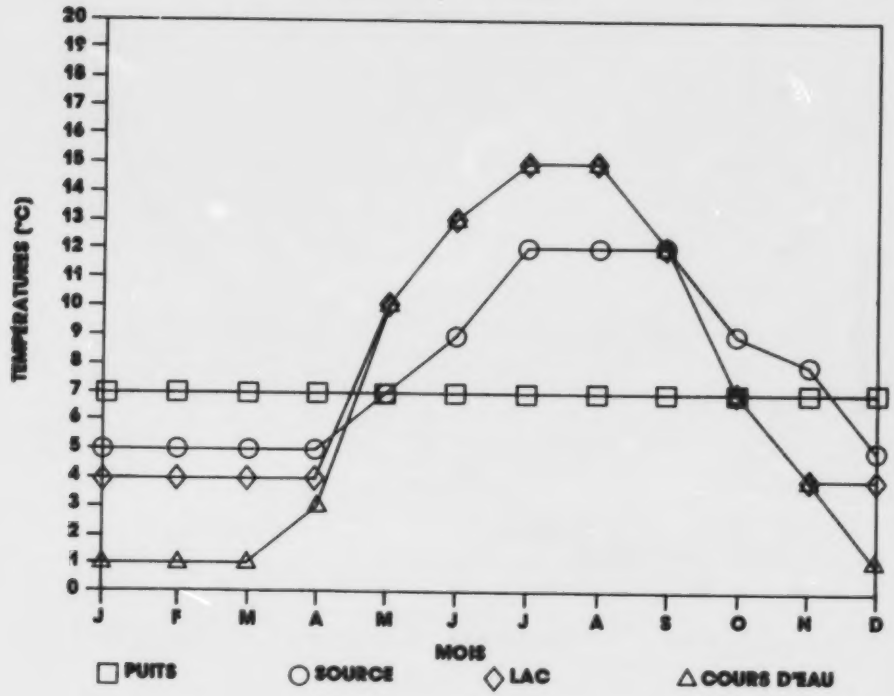
ANNEXE 4

DURÉE DE L'INCUBATION



ANNEXE 5

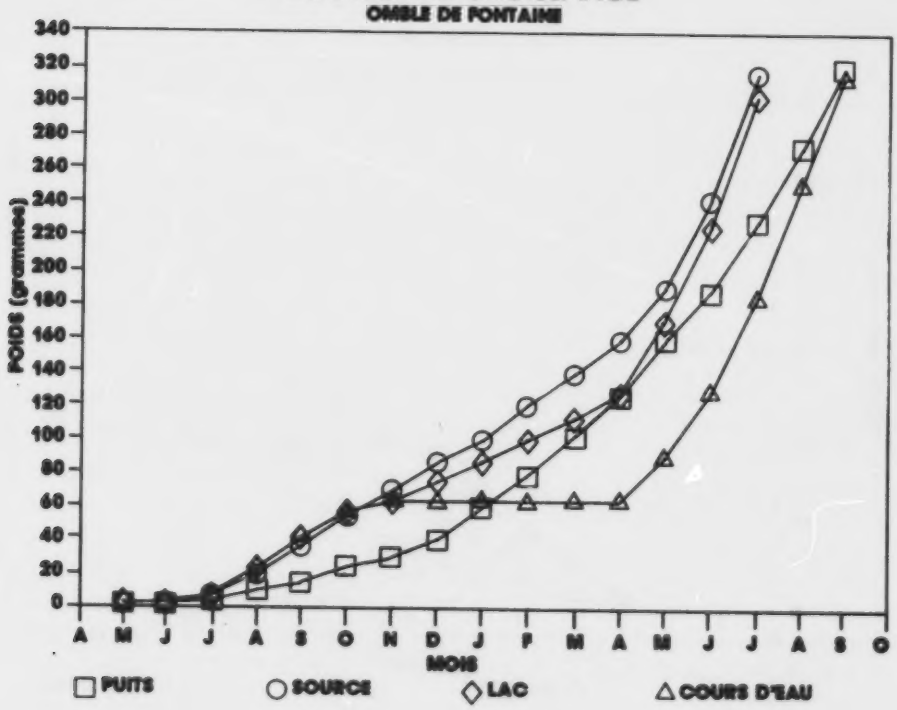
TEMPÉRATURES MOYENNES MENSUELLES



ANNEXE 6

COURBES DE CROISSANCE

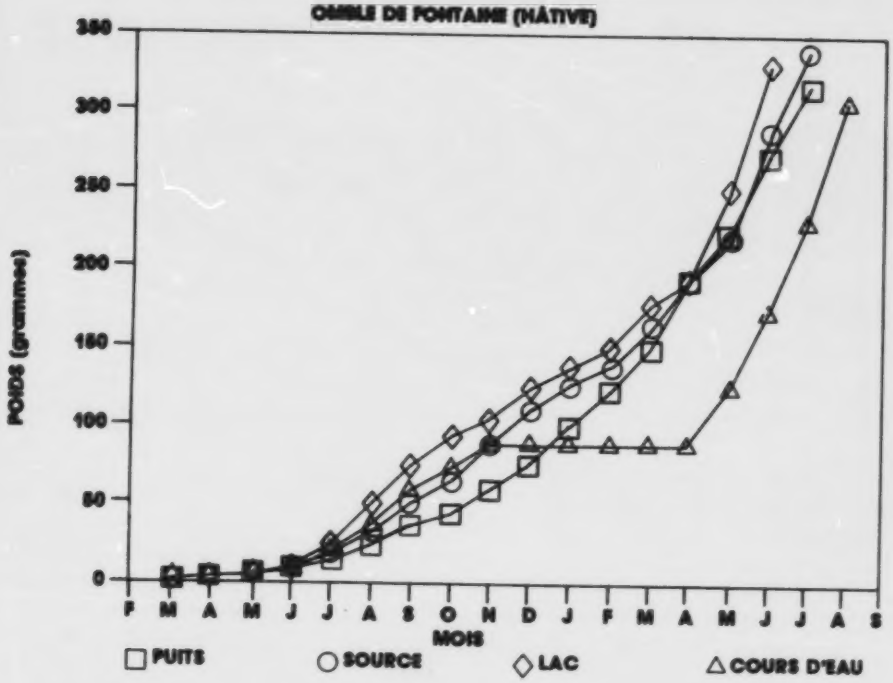
OMBLE DE FONTAINE



ANNEXE 7

COURBES DE CROISSANCE

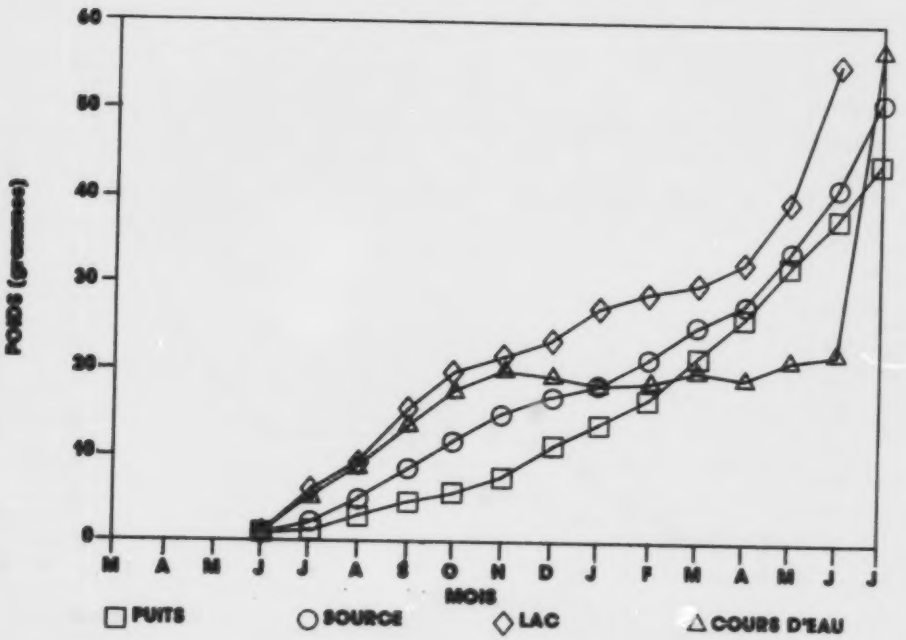
OMBLE DE FONTAINE (HÂTIVE)



ANNEXE 8

COURBES DE CROISSANCE

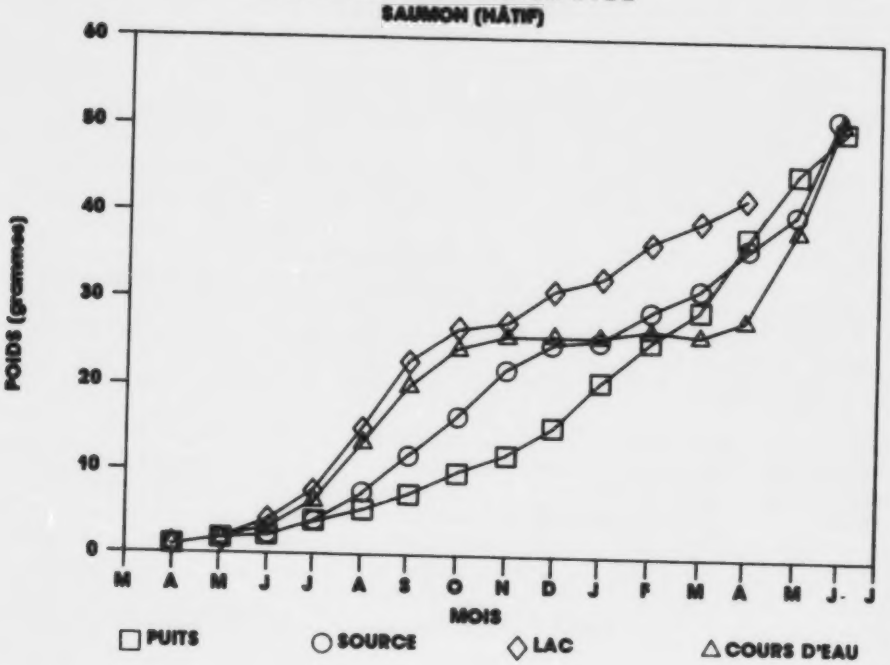
SAUMON



ANNEXE 9

COURBES DE CROISSANCE

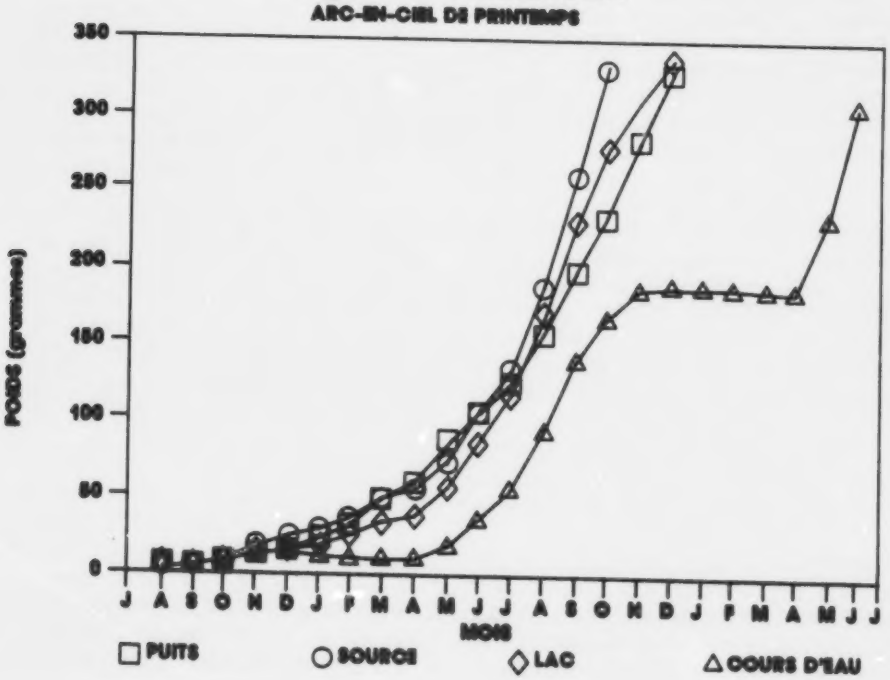
SAUMON (HÂTIF)



ANNEXE 10

COURBES DE CROISSANCE

ARC-EN-CIEL DE PRINTEMPS



ATLANTIC MARINE WATER RESOURCES: THEIR UTILIZATION AND POTENTIAL FOR AQUACULTURE

by R.H. Cook, F. Sander and R.E. Drinnan

ABSTRACT

The pace of aquaculture development has accelerated throughout Atlantic Canada with several species now being commercially produced. The extensive coastline and waters of the region hold promise for expansion of aquaculture; however, the marine environment poses serious constraints for development. The nature of the coastline, and such factors as currents, waves, tides, ice cover and, most significantly, water temperature and salinity, have severe influences on development potential. Similarly, water quality parameters, pollution, primary productivity and the occurrence of paralytic shellfish poisoning can severely restrict aquaculture development opportunities.

An assessment of the marine aquatic environment in Atlantic Canada is provided in the context of those parameters of direct relevance to aquaculture development. The region has been broken down into five generalized zones and these are described in environmental terms with existing and potential opportunities in each being identified. The associated biological criteria of the more promising candidate species for Atlantic aquaculture are described along with some of the technological opportunities that should allow a broadened application of the marine water resources.

RÉSUMÉ

Le pas du développement de l'aquiculture dans la région atlantique du Canada s'est grandement accéléré et quelques espèces sont maintenant produites commercialement. Grâce au vaste littoral, les eaux côtières de la région sont prometteuses pour l'expansion de l'aquiculture. Cependant l'environnement marin présente de sérieuses difficultés au développement. La nature du littoral ainsi que des facteurs, tels que les courants, les vagues, les marées, l'étendue des glaces et, d'importance majeure, la température et la salinité de l'eau ont une influence rigoureuse sur les possibilités de développement. La qualité de l'eau, la pollution, la productivité primaire et l'occurrence d'empoisonnement paralytique par les mollusques peuvent, d'une manière semblable, sévèrement limiter les occasions de développement de l'aquiculture.

Une évaluation de l'environnement aquatique marin dans la région atlantique du Canada, notamment des paramètres applicables au développement de l'aquiculture, est incluse. La région est divisée en cinq zones décrites d'après la qualité de l'environnement, et les possibilités actuelles et futures de chacune sont identifiées. Les critères biologiques nécessaires pour l'aquiculture des espèces les plus prometteuses dans la région atlantique ainsi que les possibilités technologiques permettant une utilisation plus étendue des ressources marines sont décrites.

INTRODUCTION

Commercial aquaculture in Atlantic Canada has taken a long time to demonstrate its significance as a major economic opportunity and initiative in a region of Canada where socioeconomic progress has traditionally been difficult. The use of fish culture technology, particularly for the enhancement of Atlantic salmon, has its origins in the Maritimes at the time of Confederation.

There have been attempts to augment the natural production of lobster by means of hatcheries in the early 1900's; unfortunately, these efforts proved unsuccessful. The culture of the American oyster, and its production in several parts of the Maritimes, e.g. specific embayments in Prince Edward Island, New Brunswick, Bras d'Or Lakes, has for many years represented the major commercial aquaculture product produced in Atlantic Canada. Commercial salmonid production, initially rainbow trout, and, increasingly Atlantic salmon, is now taking the commercial lead. Mussel culture is also becoming well established, especially in the Gulf of St. Lawrence and the Atlantic coast of Nova Scotia.

A number of other candidates are actively under consideration or under research in laboratories, in pilot scale, or under experimental commercial applications (Aiken, 1984). The European oyster, bay scallop, quahog and the giant scallop all hold particular promise. The "sea ranching" of tuna in St. Margaret's Bay, N.S., represented an opportunistic situation; unfortunately, this form of tuna aquaculture was totally dependent on the availability of wild stock populations and the lack of tuna in St. Margaret's Bay has impeded further development of this industry. Seaweed culture too depends predominantly on natural sources of algae and the management of these resources to optimize yield at time of harvesting. The commercial potential for seaweed products utilizing enhanced cultivation technologies is also significant in the region.

The prospects for commercial lobster aquaculture show increasing promise. With strong scientific backup from several well-established research programs, an extensive data base on the biological and nutritional requirements for the culture of lobster, from egg to adult, is available. Lobster-holding systems, using advanced technology, are already in operation in Nova Scotia and plans are underway for a major lobster grow-out facility in P.E.I.

Most of the above developments have resulted from the ready access to seedstock in certain geographic areas and from beneficial environmental features that have allowed production to proceed at a commercial scale. The suitability of the marine environment and the utilization of the water resource remain the major factors governing the growth of aquaculture in Atlantic Canada. The purpose of this paper is to provide an overview of the general environmental conditions as they pertain to marine aquaculture, to consider the basic biological requirements of the leading candidate species for commercialization, and to identify some technological applications that would mitigate against environmental constraints.

In the review of the environmental conditions in Atlantic Canada as they relate to marine aquaculture, it became evident taht the Atlantic east coast could be divided into five aquaculture zones. These have been determined on the aquatic environmental factors that have a major influence on aquaculture production. It is to be realized, however, that there are always exceptions to generalizations.

The Atlantic marine water resources for aquaculture activities have therefore been divided into five environmental zones on the basis of physical and biological oceanography, coastal geomorphology and climatology. These regions have been loosely defined as "aquaculture environmental zones" and are presented in Figure 1 as follows:

Zone 1 — Bay of Fundy
Zone 2 — Atlantic coast of Nova Scotia
Zone 3 — Bras d'Or Lakes, Nova Scotia
Zone 4 — Southern Gulf of St. Lawrence
Zone 5 — Atlantic coast of Newfoundland

Within these zones, sometimes there are special hydrographic or geographic anomalies which can provide distinctive advantages and special opportunities for aquaculture. For example, in Zone 1, Kennebecasis Bay, near the mouth of the Saint John River, has a sill at its mouth which retains at depth the warmer, more saline waters of the Bay of Fundy in winter, distinct from the predominant freshwater regime of the river itself. This special water resource has special promise for salmonid aquaculture, both for shore-based facilities as well as the application of new sea-cage technologies. In Zone 3, the waters of Little Narrows Pond, in the Bras d'Or Lakes, present a similar unique source of water highly amenable for salmonid aquaculture. In Zone 4, Malpeque Bay and the "rivers" that drain into it provide exceptional conditions of nutrient availability and physical conditions highly conducive to molluscan culture. As our knowledge of the marine environment expands and with the advancement of aquaculture technology, other "pockets" of unique marine water resources will be identified and developed.

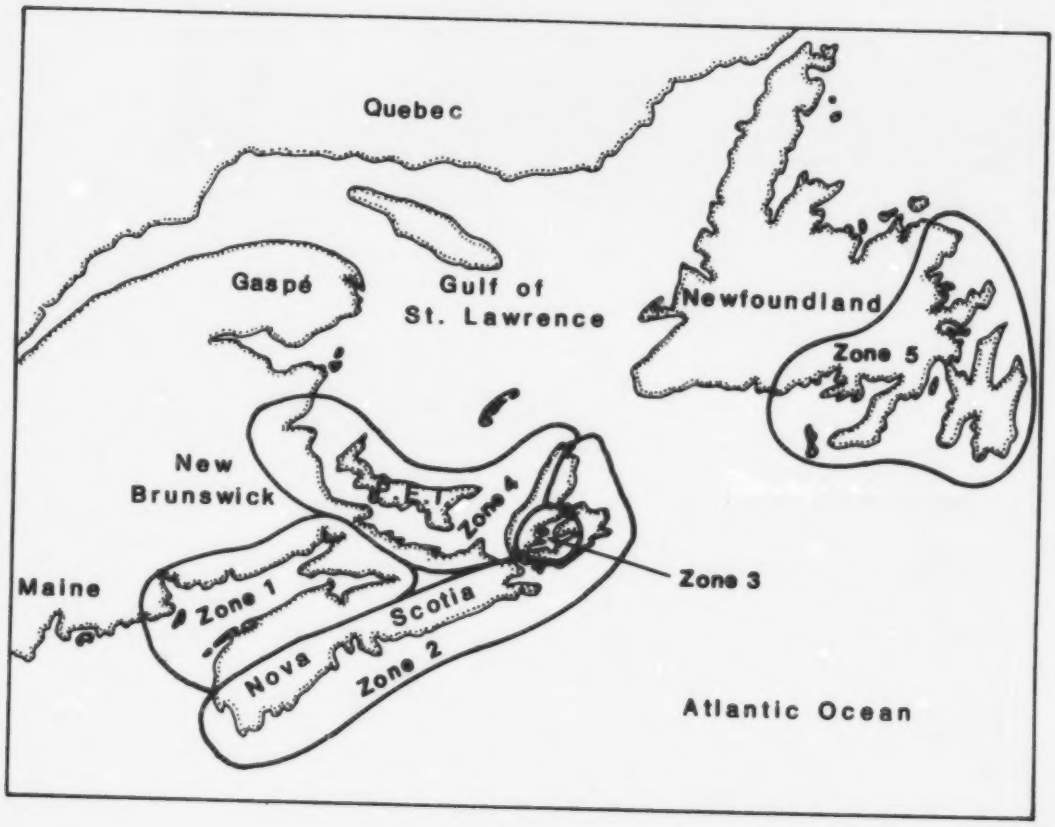


FIGURE 1:
LOCATIONS OF ENVIRONMENTAL ZONES 1 (BAY OF FUNDY), 2 (ATLANTIC COAST OF NOVA SCOTIA), 3 (BRAS D'OR LAKE), 4 (GULF SHALLOW REGIONS) AND 5 (ATLANTIC COAST OF NEWFOUNDLAND).

The commercial development of aquaculture in Atlantic coastal waters is expanding rapidly in all the environmental zones described above; marine environmental conditions, however, will strongly influence the species and type of aquaculture that will ultimately be viable. To enable such considerations, a brief review of the characteristics of each "aquaculture environmental zone" is presented.

AQUACULTURE ENVIRONMENTAL ZONES

The Atlantic marine environment has been arbitrarily divided into five basic aquaculture environmental zones based primarily on the nature of the physical environment as well as the existing commercial applications of aquaculture. These zones include 1) the Bay of Fundy, 2) the Atlantic coast of Nova Scotia, 3) the Bras d'Or Lakes, 4) the shallow regions of southern Gulf of St. Lawrence and 5) a portion of the Atlantic coast of Newfoundland. They are described separately with a view to facilitate the evaluation of their characteristic features against the biological requirements of the various aquaculture species, and in anticipation that they will meet these requirements to various degrees indicative of their respective potential for aquaculture endeavours. Figures 2-9 and 11 convey information on coastal geomorphology, wave heights, wind speeds, tidal ranges, ice conditions, suspended particulate matter and paralytic shellfish toxins and bacterial contamination distribution for the regions and will be referred to in the following descriptions.

Zone 1: Bay of Fundy

The Bay of Fundy environmental zone includes the coast of southwest New Brunswick and the coastal area of Nova Scotia extending from the New Brunswick border to the southwest shore of Nova Scotia above Yarmouth. Figure 2 depicts roughly the coastal geomorphology of these coastlines to

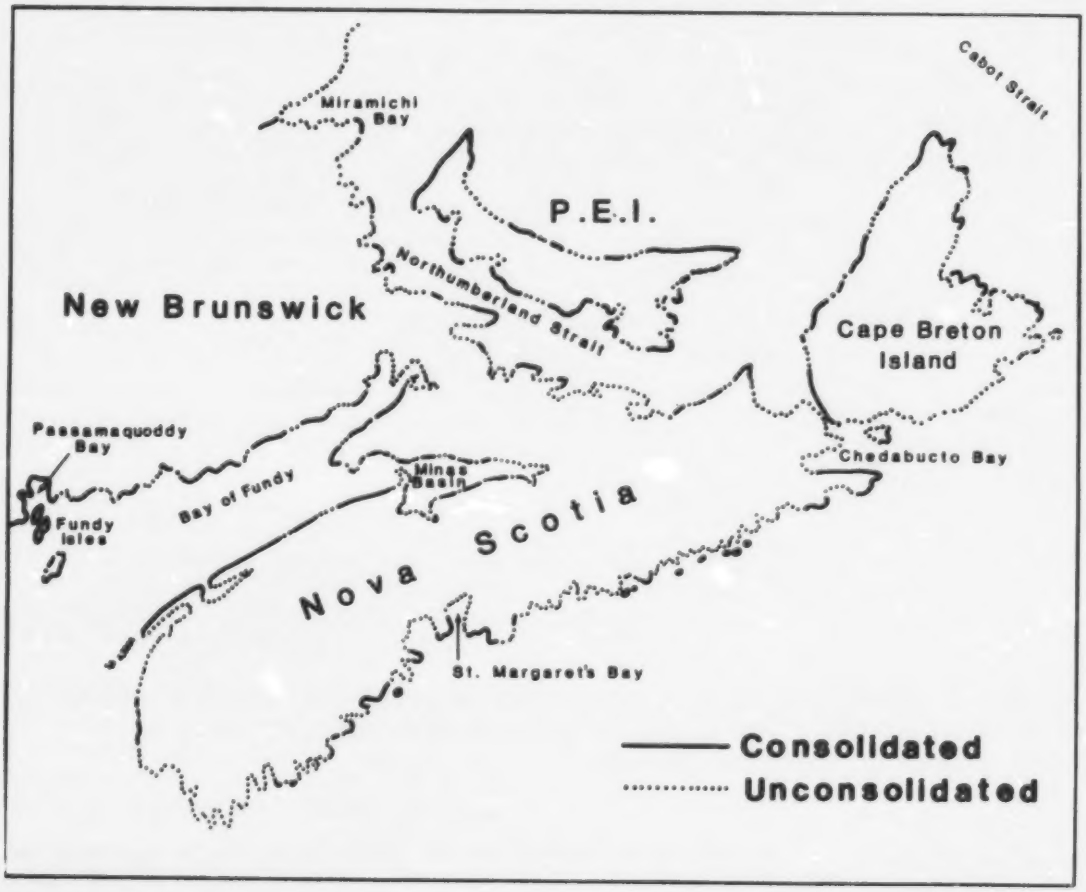


FIGURE 2:
COASTAL GEOMORPHOLOGY OF ATLANTIC SHORES OF NOVA SCOTIA
(courtesy of Atlantic Geoscience Centre, Bedford Institute of Oceanography).

the extent that they are either consolidated (predominantly lithofied rock) or unconsolidated (predominantly beach). The illustration is adapted from a large draft map provided by the Atlantic Geoscience Centre, Bedford Institute of Oceanography (BIO), which also details deltas, estuaries, marshes and tidal flats. The types of shoreline and nearshore substratum may have operational implications for the prospective aquaculturists and may also determine the suitability for accommodating the various molluscan aquaculture species. The area between the Saint John and St. Croix Rivers is of special interest, insofar as it is highly irregular with many small inlets and islets, bays, and estuaries. It includes the Fundy Isles, viz. Campobello, Deer Island and Grand Manan, and such inland estuaries as L'Étang Inlet, Musquash Harbour and Kennebecasis Bay. A coastal zone management study of the New Brunswick portion of the Bay of Fundy coastal zone (Hunter and Associates, 1982) offers an excellent map and photographic atlas series for detailed information.

Figures 3 and 4 illustrate wave and wind conditions for Atlantic Canada, including the Bay of Fundy. As one would expect, the wave distribution pattern resembles quite closely that of the mean wind speed. Winds in the Bay blow principally from the south and southwest during the summer, but for the remainder of the year, are mainly from the west and northwest. Consequently, as the Bay of Fundy is oriented approximately east to west, the unprotected coasts are generally exposed. However, high incidence of strong winds is chiefly a winter phenomenon, and, along the Fundy coast and parts of the south shore of Nova Scotia, wind speeds greater than 25 miles per hour normally occur not more than 10% of the time in any month (Anon., 1976). The Bay of Fundy is noted for the fact that in one of its two inner branches (the Minas Basin), the rise and fall of the tide is greater than any known elsewhere in the world, the extreme

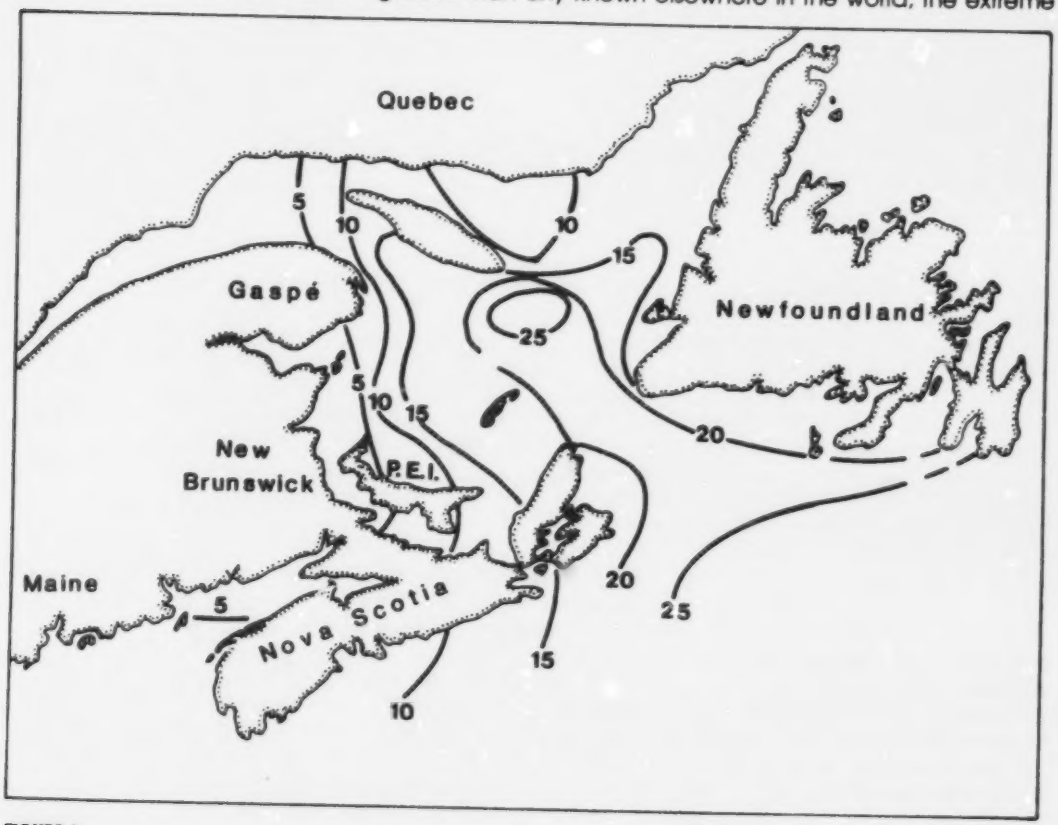


FIGURE 3:
PERCENTAGE OF WAVES GREATER THAN TWO METERS
(adapted from Anon., 1976).

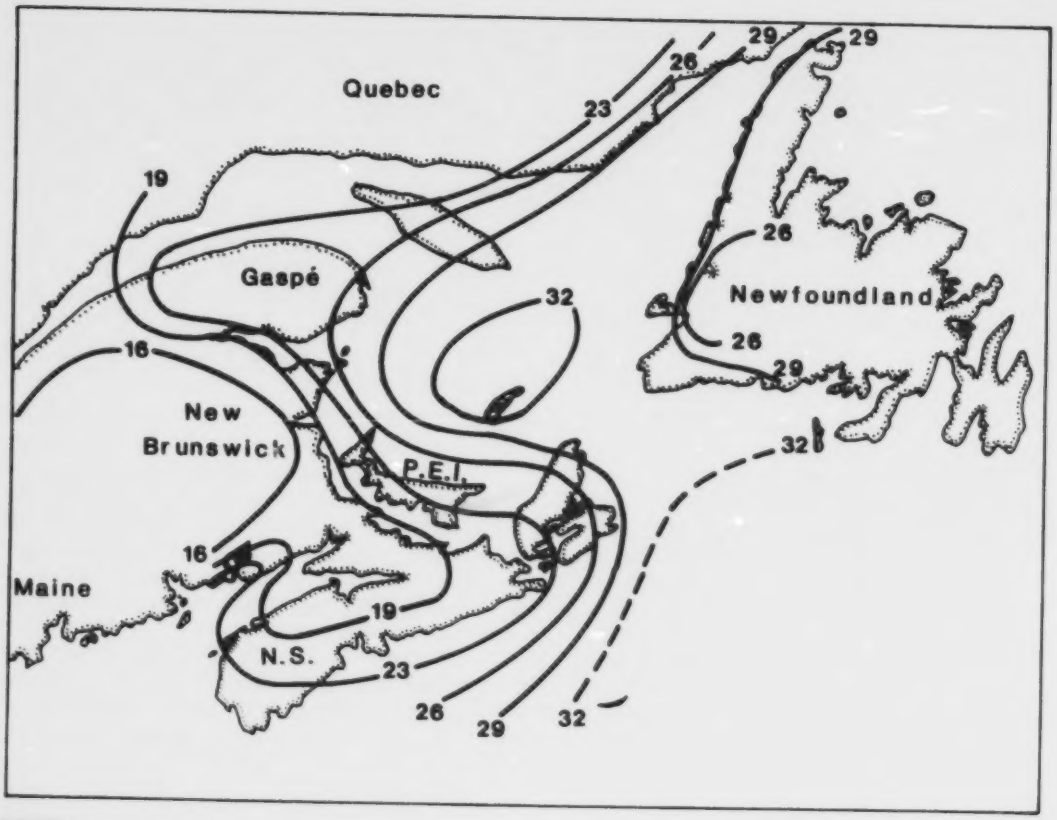


FIGURE 4:
MEAN WIND SPEEDS DURING WINDIEST MONTH OF THE YEAR (IN KILOMETERS PER HOUR) (adapted from Anon., 1976).

range being 16 m (Stephenson and Stephenson, 1954). Figure 5 shows the tidal range for large tides in the Bay of Fundy. Tidal oscillations have created a unique situation, of special interest to aquaculturists, at Kennebecasis Bay, a stratified fjord-like body of water about 26 km long. It is connected to the Saint John River 9 km above the city of Saint John, N.B., where the river flows into the Bay of Fundy. A comprehensive report (J.M. Anderson Consultants Inc., 1982), investigating the use of this Bay for salmon aquaculture, describes the unique geological and oceanographic features, which provide the mechanism for renewal of a deep saline layer of the Bay (and thus the potential for aquaculture).

Kennebecasis Bay, where depths reach 70 m, can be visualized as a giant bathtub. There is a shallow sill, where it meets the Saint John River, and another at the Reversing Falls at the mouth of the river. The resultant deep gorge between those two sills serves as a "mixing bowl" for river water and seawater at flood tides. Intrusions (i.e. deep saline layer renewals) into the Bay appear primarily to be a function of the discharge rate of the Saint John River, and, secondarily, of high tide level. Low discharge rates result in increased salinity of the water in the "mixing bowl", and, if this water is of sufficiently high density, it will flow over the sill at the Bay's mouth during flood tide and displace old water. The salinity of the deep saline water apparently remains fairly constant at 20 o/oo year-round.

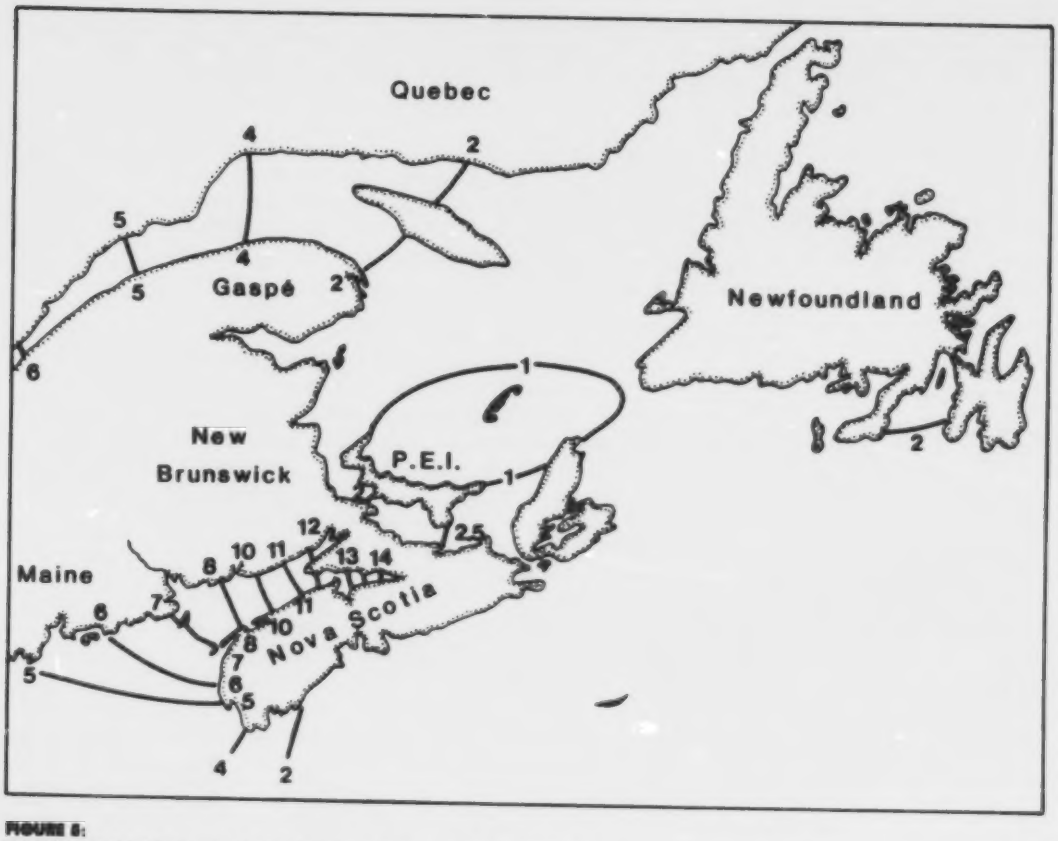


FIGURE 8:
TIDAL RANGE (IN METERS) FOR LARGE TIDES
(adapted from Anon., 1976).

Renewal of saline water normally occurs in the summer, when river discharge is low, and again in the winter, when precipitation takes the form of snow and run-off is low. It is the summer intrusions, with incoming seawater averaging 15°C, which afford the opportunity for aquaculture; although winter intrusions bring in cold water, warmer remnant water, suitable for aquaculture, remains throughout the winter months above the fresh input of colder, denser seawater.

Temperature and salinity are important environmental variables, which dictate the distribution of marine species, and, consequently, the potential grow-out sites for those suited for aquaculture. McGuire (1977) mapped summer and winter seawater temperatures for the Bay of Fundy. Values are low for the region, although typical for a body of water where there is a big tidal movement into a funnel-shaped bay. But temperature regimes vary from year to year, especially close to shore in protected areas (suitable for aquaculture), where they often are very localized. Moored Ryan thermograph records (courtesy of Data Archive Centre, Coastal Oceanography Division, BIO) for the Canadian east coast for the 1978-1985 period show extreme summer (July) and winter (February) surface temperature of 0.9°C (Annapolis Royal, N.S.) and 15.7°C (Kennebecasis Bay, N.B.). At the Biological Station, St. Andrews, at the head of Passamaquoddy Bay, the coldest monthly mean temperature between 1964 and 1985 was −0.1°C (February 1971) and the warmest 15.0°C (August 1976). Extreme mean surface temperatures at the mouth of the Bay for the period 1951-1980 were 1.9°C (February) and 11.6°C (August) (Drinkwater, 1986). Monthly mean salinity extremes for the same period were 30.54 o/oo (May) and 32.46

o/oo (October). These data are generally indicative of the entire Bay of Fundy, although pronounced gradients exist in the estuaries. Hachey (1952), for example, observed a gradient from the mouth of the Bay of the Chignecto region of 32.89 o/oo to less than 31.0 o/oo.

Connected to temperature (and geography) are ice conditions, which for practical reasons can be important to aquaculture operations in given areas. Average spring ice conditions for the Canadian east coast are shown in Figure 6. The Bay of Fundy is beyond the realm of major sea ice accumulations; and what little ice does form during cold snaps quickly melts of is broken up by wave action and carried out to sea (Anon, 1976).

A requisite to successful culturing of filter-feeding bivalves, such as mussels, scallops and oysters, is an adequate supply of food. As such, productivity of seawater at a prospective aquaculture site is of interest. Prouse et al. (1984) have calculated annual production in different regions of the Bay of Fundy based on the results of previous studies (Gran and Braarud, 1935; Subba Rao, 1975; Hargrave et al. 1983; Prouse, 1983). Their results showed a sharp productivity gradient from 15-17 g C/m²/yr in the two inner basins, 27 g C/m²/yr in the Inner Bay, to 133 g C/m²/yr in the Outer Bay (roughly beyond an imaginary line between Saint John, N.B., and Digby, N.S.). In part, the gradient results from a reserve gradient in turbidity. Diatoms are the most abundant phytoplankton group with the benthic diatom, **Paralia sulcata**, and the oceanic from, **Actinoptychus senarius** the dominant species. Maximum (summer) and minimum (winter and early spring) chlorophyll values of surface waters at the mouth were 3.3 µg/L and 0.5 µg/L, respectively.

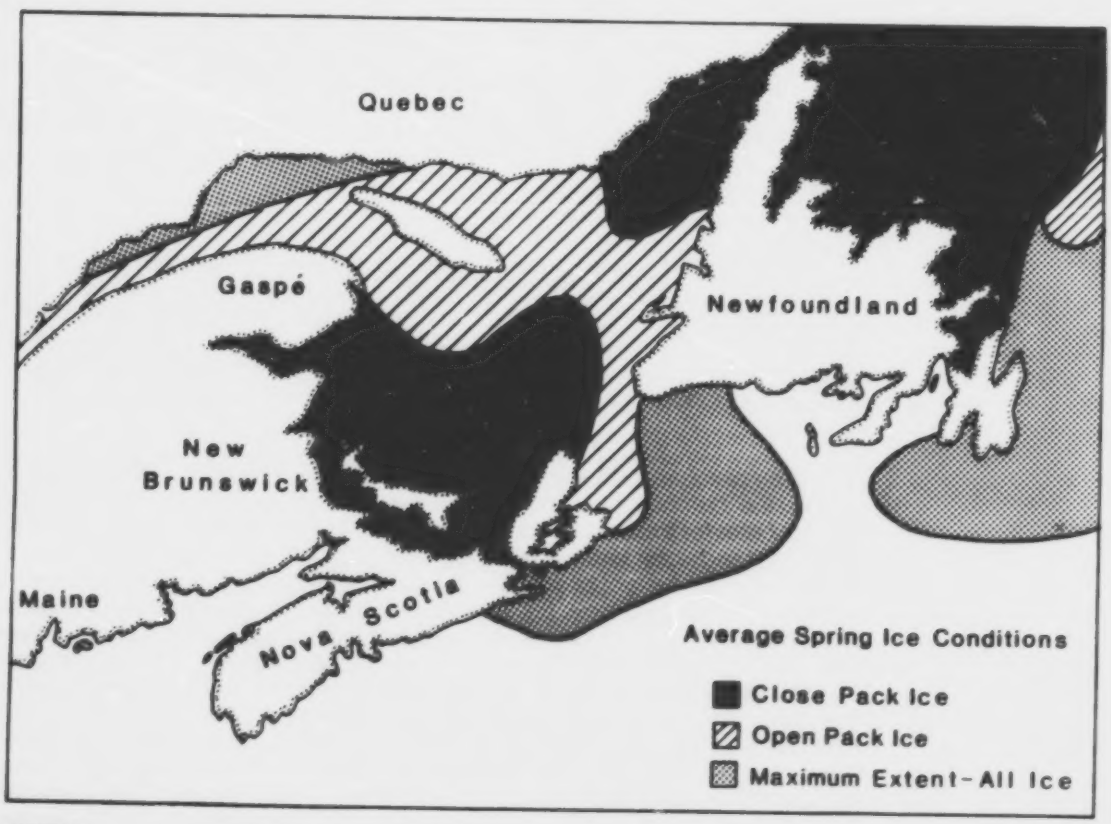


FIGURE 6:
AVERAGE SPRING ICE CONDITIONS
(adapted from Scarratt, 1982).

While it is important to the aquaculturist that particle concentrations are not reduced substantially below the capacity of individual bivalves to ingest and assimilate food energy, it is, conversely, also important they not be burdened with concentrations sufficiently high to be deleterious to their physiological state of health, as may be the case where suspended sediment loads are high. Figure 7 illustrates the distribution of particulate matter concentrations in the Bay of Fundy (K. Kranck, pers. comm.). Particulate organic matter content predictably comprises a small fraction in waters of the inner reaches of the Bay, where the suspended sediment load may be as high as 100 mg/L in the Cumberland Basin (Gordon and Baretta, 1982). Temporal variations are expected and may be detected on an hourly basis. For example, suspended solids, measured during low water in the lower L'Étang, N.B., (unpubl. data, H.M. Akagi and A.J. Wilson, cited in Wildish et al., 1986) showed the following hourly variation sequence: 5, 15, 8, 13 and 9 mg/L.

Red tides may pose a serious problem for aquaculturists. **Gonyaulax excavata**, the dinoflagellate responsible for "paralytic shellfish poisoning (PSP)" and fish kills in eastern Canada, is particularly prevalent in the Bay of Fundy (Figure 8), where extensive areas beyond the head of the Bay are subject to periodic closure due to risk of PSP. (There is no evidence of toxin production in this region by phytoplankters other than **G. excavata** (Needler, 1949; Prakash, 1963, 1967; Prakash et al., 1971)). A comprehensive summation of information on PSP and shellfish toxicity in Atlantic Canada, including details of the PSP control program, was published by Prakash et al. in 1971. White (1982), however, reported that in the ensuing 10 years there had been intensification of **Gonyaulax** blooms and the shellfish toxicity problem had increased during the 1970's and its complexion changed. In this connection, White and Lewis (1982) demonstrated that resting cysts of **G. excavata** were widely dispersed in the Bay, occurring both offshore and inshore, including the intertidal zone.

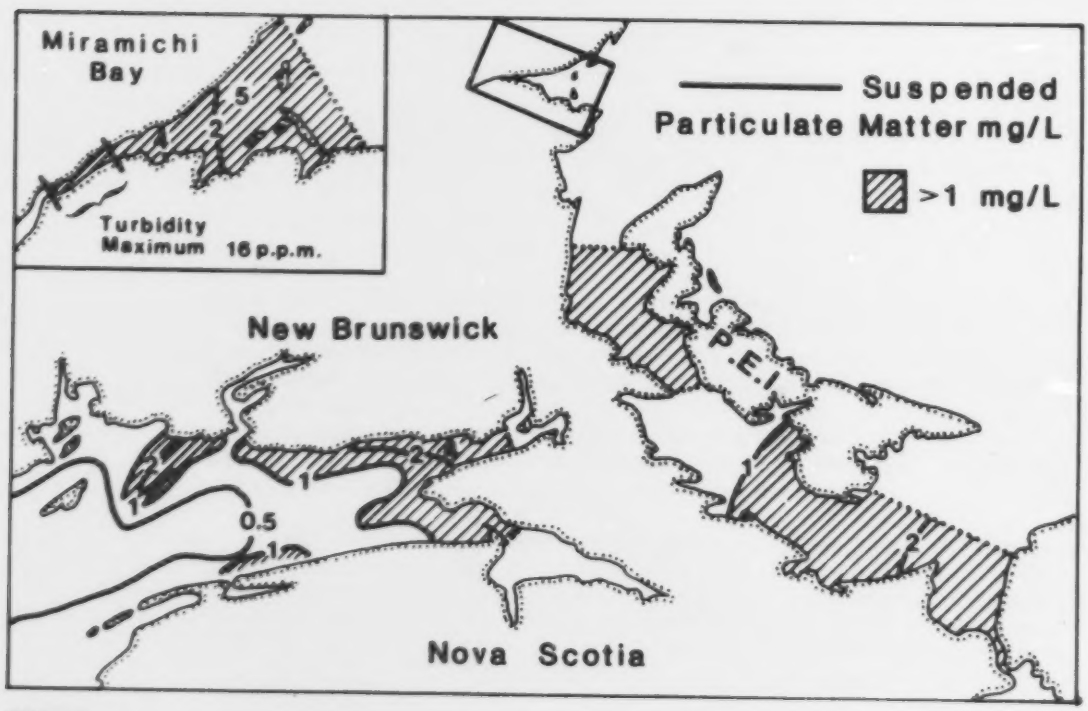


FIGURE 7:
SUSPENDED PARTICULATE MATTER CONCENTRATIONS IN BAY OF FUNDY AND GULF SHALLOW REGIONS
(courtesy of K. Kranck).

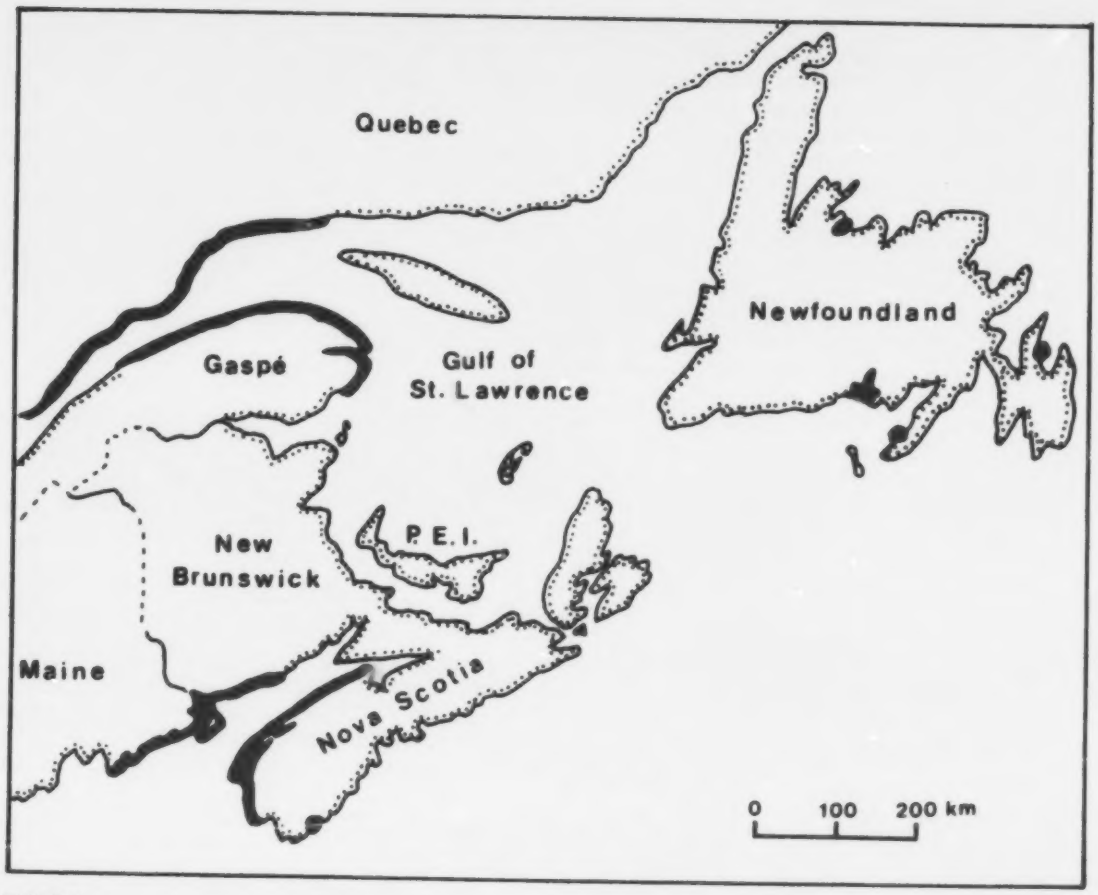


FIGURE 8:
PARALYTIC SHELLFISH TOXIN OCCURENCE IN ATLANTIC CANADA
(courtesy of J.L. Martin).

Further, White (1982) also noted that the impact of the blooms had amplified to include effects on finfish, as well as shellfish, resources. This was first documented the previous year (White, 1981) in a revealing study on the sensitivity of marine fishes to toxins from **G. excavata** and the attendant implication for fish kills.

In addition, many bays and inlets in the area are also closed due to bacterial contamination usually associated with anthropogenic causes (Figure 9).

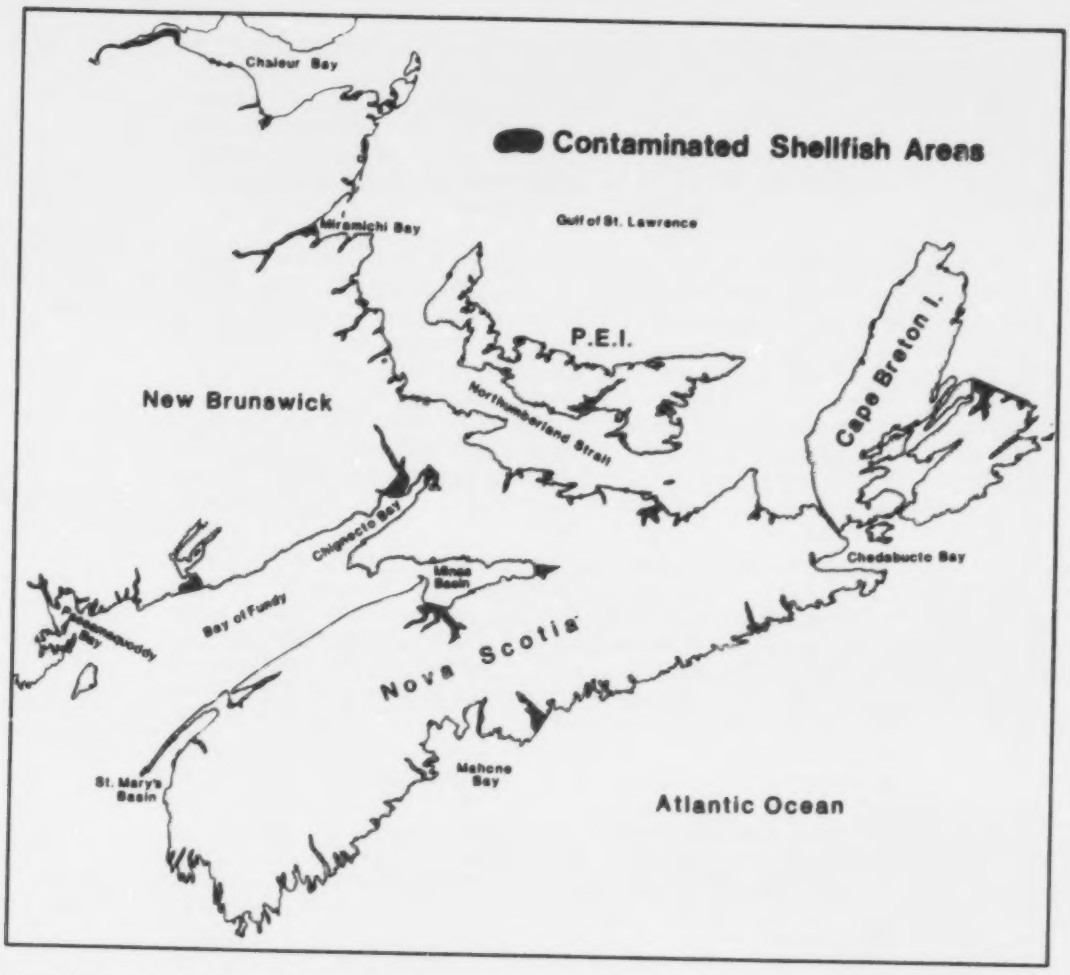


FIGURE 9:
SHELLFISH AREAS CLOSED DUE TO BACTERIAL CONTAMINATION
(adapted from Maritimes Fisheries Guide — Fisheries and Oceans, Environment Canada, N.B. Department of Environment, N.B. Department of Fisheries, N.S. Department of Environment, and Government of P.E.I.).

Zone 2: Atlantic Coast of Nova Scotia

This environmental zone stretches from the south shore of Nova Scotia to the southernmost tip of Cape Breton Island (Figure 1). Figure 2 denotes the consolidated and unconsolidated components of the shores. An environmental atlas of eastern Nova Scotia (McGuire, 1980) is available for a detailed description of the coastal zones, which also accentuates the myriad of bays, inlets, peninsulas, and islets characterizing most of the shoreline.

Wave and wind climates are featured in Figures 3 and 4. Increasing south-to-north gradients exist for both wave height and wind speed. As such, highest percentage of rough seas are found along the shores of Cape Breton Island in the Cabot Strait. Winds over most of the east coast show a distinct seasonal variation. Typically, December and January are the windiest months averaging about 50% higher than in July and August, normally the months of lightest winds (Anon., 1976).

Tides are significantly less than in the Bay of Fundy (Figure 5) and decrease rapidly with increasing distance from the Bay. Average tides for nearly all of the east coast is less than 2 m.

Ryan thermograph records for the period 1978-1985 manifest significant variations in maximum summer and minimum winter seawater (0-10 m) temperatures according to locality. Winter lows of 0°C were measured in February at Pleasant Point Pound and Argyle Sound. Summer highs above 20°C were recorded at Ingonish (September) and Tracadie Harbour (July and August). It should be noted, though, that Connor (1986) reported a number of inshore sample sites, where sub-zero readings were observed.

Salinity date (courtesy of Data Archive Centre, Coastal Oceanography Division, BIO) derived from current meters off the southern shore of Nova Scotia between May and November, 1984 showed maximum and minimum values at 10 m of 30.75 o/oo and 33.53 o/oo, respectively. Off Halifax, salinities as low as 29 o/oo are seen with the passage of the low salinity pulse in the fall; during the remainder of the year, salinities of 31-31.5 o/oo are observed (Scarratt, 1982). Again, lowest salinities are obtained in bays and inlets where sources of freshwater discharge exist. For example, Platt and Irwin (1972) reported instances in Petpeswick Inlet, when salinity at their sampling station (normally above 25 o/oo) measured less than 20 o/oo.

Throughout much of the winter, ice spills out of the Gulf of St. Lawrence through the Cabot Strait (Figure 6). At the earliest, ice appears in the Strait towards the end of January. At the latest, it lingers until early June. The ice tends to drift southward through the Strait, along the Cape Breton shore, then westward around Scatarie Island, occasionally reaching Chedabucto Bay and beyond (Anon., 1976). South of Halifax, shore-ice formation may appear during periods of cold weather, but it rarely remains for long.

Phytoplankton production data have been collected for St. Margaret's Bay, Bedford Basin and Petpeswick Inlet. Platt (1971) reported a maximum primary production rate of 226.6 mg C/m²/hr (1812.8 mg C/m²/day) in July, 1968, at a station in St. Margaret's Bay. A minimum value of 21.8 mg C/m²/hr (113.2 mg C/m²/day) was obtained in December. Platt and Irwin (1968) reported a spring peak of 168 mg C/m²/hr in April, 1967. At the end of the spring bloom, production was reduced to the winter level of 10 mg C/m²/hr, but quickly recovered by June 1 and for the rest of the year oscillated about a mean of 60 mg C/m²/hr. The highest chlorophyll concentration observed at 1-10 m in the spring bloom was 10.28 mg/m³.

The annual production in Bedford Basin is not much higher than in St. Margaret's Bay, for although it is considerably more enriched, it is also more turbid and the available light for photosynthesis correspondingly lower (Platt and Conover, 1975). A May to December, 1971, and April to May, 1972, study in Petpeswick Inlet by Platt and Irwin (1972) revealed maximum and minimum primary productivity values at a 24 m sample site of 141.6 mg C/m²/hr (September) and 0.4 mg C/m²/hr (March), respectively. Corresponding chlorophyll values were 54.59 mg/m² (6.41 mg/m³ at 1 m) and 6.43 mg/m² (1.00 mg/m³ at 1 m).

The above-mentioned phytoplankton productivity studies are clearly not representative of every bay along the Atlantic coast of Nova Scotia, but do serve to demonstrate the seasonal variability and approximate range of primary productivity levels likely to exist in other localities of this environmental zone.

Kranck (1980) studied the variability of particular matter in Petpeswick Inlet, which is perhaps typical of many such indentations of the Atlantic coast of Nova Scotia. She identified four basic types of particle populations, based on size spectra, the occurrence of which varied with season and location in the inlet. These four types varied in total concentration between 1) 1.4 to 6.2 ppm (by volume), 2) 1.0 to 12.4 pmm, 3) 1.4 to 6.5 ppm and 4) 0.7 to 1.2 pmm (1 ppm by weight converts to ca. 1.3 ppm by volume (K. Kranck, pers. comm.)).

Recent particulate matter (unpubl. data, N.S. Dept. Fish.) obtained from 12 Bay scallop sites (August-December, 1986) throughout the Province (Figure 10) show the particulate organic matter level at most inshore stations to be quite low (Table 1) compared to the recommended values for molluscan culture reported in the literature. It is perhaps noteworthy that the range in levels of particulate organic matter (POM) throughout the Province was relatively narrow.

TABLE 1:

PARTICULATE MATTER LEVELS (mg/L) AT 12 BAY SCALLOP STUDY SITES IN NOVA SCOTIA BASED ON MONTHLY (3 replicates) DETERMINATIONS FOR THE PERIOD AUGUST TO DECEMBER, 1986.

Site	TPM	PIM	POM	Ratio POM/TPM
1. Chance	3.59	2.48	1.11	0.31
2. Tracadie	4.75	3.73	1.02	0.21
3. Aulds	2.73	2.08	0.65	0.24
4. Whitehead	1.33	0.78	0.56	0.42
5. Spanish Ship Harbour	1.93	1.06	0.87	0.45
6. Ship Harbour	2.89	0.98	1.91	0.20
7. Ostrea	1.28	0.64	0.63	0.49
8. Bedford Basin	1.54	0.79	0.75	0.49
9. Mahone Bay	2.28	1.66	0.62	0.27
10. Medway Harbour	2.32	1.43	0.89	0.38
11. Barrington Bay	4.29	2.29	1.23	0.29
12. Argyle	2.57	1.77	0.79	0.31

TPM = Total Particulate Matter, PIM = Particulate Inorganic Matter;
POM = Particulate Organic Matter.

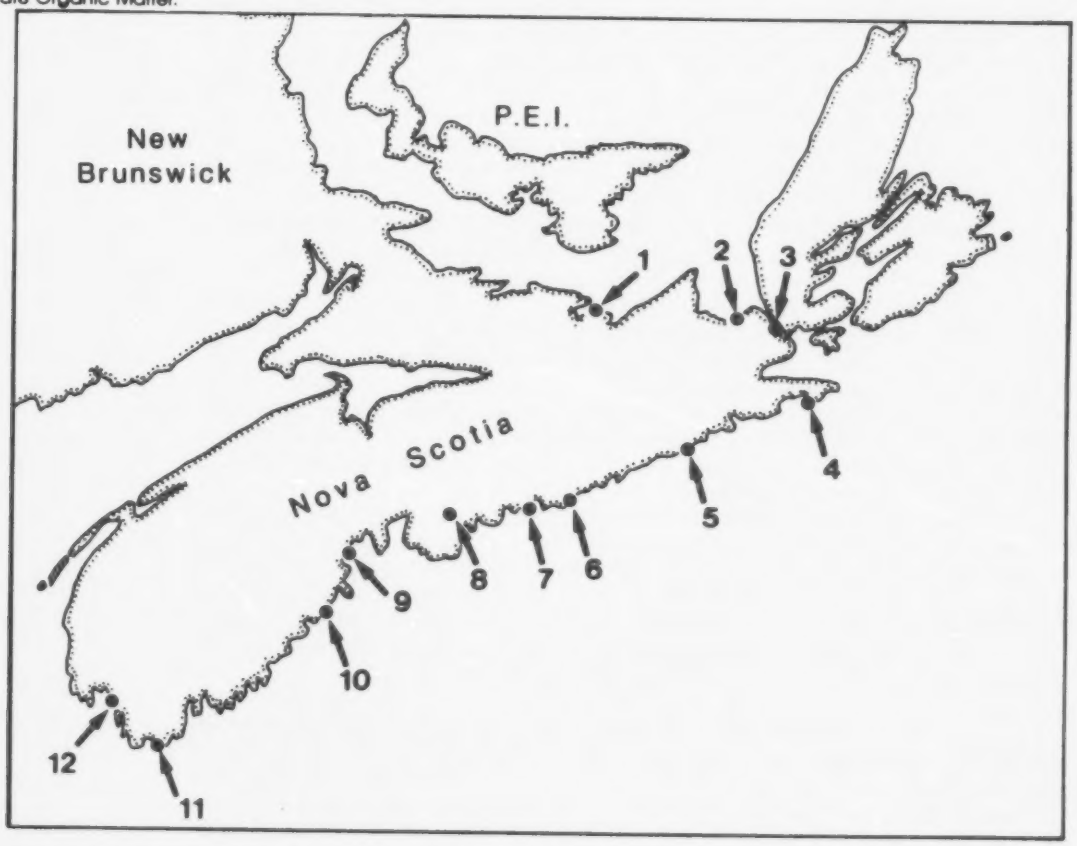


Figure 10:

SCALLOP STUDY SITES WHERE SUSPENDED PARTICULATE MATTER CONCENTRATIONS WERE DETERMINED.

Problems with paralytic shellfish poisoning have only rarely been associated with the Atlantic coast of Nova Scotia. However, in 1986 the toxin was identified in mussels in the Shelburne area near the southern tip of the province (J.L. Martin, pers. comm.) (Figure 8). A continued investigation may reveal that this is not an isolated case and that the distribution is perhaps more widespread in this zone than presently realized.

Figure 9 shows that areas closed by bacterial contamination are prevalent throughout the area and are clearly correlated to the location of villages, towns and other human activities along the shores.

Zone 3: Bras d'Or Lake

Bras d'Or Lake (Figure 1), a much convoluted inland water mass in Cape Breton Island with three channels connecting it to the Atlantic Ocean, has an area of 1050 km², a shoreline of 500 km richly endowed with coves, headlands and nearby islets, and maximum depths of 30 to 60 m in most areas (Geen and Hargrave, 1966). However, the bathymetry is highly variable with a number of major basins of extreme depth. The fauna and flora are marine, reflecting prevailing salinities from 20 to 25 o/oo. Large local salinity gradients in space and time, however, do occur in the immediate vicinity of the river mouths and in the barachois. For example, horizontal salinity gradients of approximately 5 o/oo exist in some channels caused either by freshwater runoff or by the higher salinity of the oceanic water entering the lake system (Krauel, 1975).

Unlike the ocean, the physical conditions of Bras d'Or Lake might be described as "static" (Bell and MacFarlane, 1933), inasmuch as the temperature is consistently and uniformly warm during the summer and the surface freezes over every winter. The annual temperature maximum is attained near the beginning of August and the minimum in February. Furthermore, there is virtually no tidal oscillations (the tide entering Bras d'Or Lake has been attenuated to only 0.15 m or less), and, except in the narrow channels connecting the ocean with the lake, the currents are relatively weak. The surface is typically calm, and even storm-related waves are not significant and soon die down. An excellent summary of the physical oceanography of the Bras d'Or Lake system has been offered by Krauel (1975).

Geen and Hargrave (1966) calculated net primary production rates in Bras d'Or Lake. During the summers of 1961 to 1963 inclusive, rates were generally 20 to 40 mg C/m²/hr, 200 to 300 mg C/m²/day and estimated at 55 g C/m²/yr. In general, there were no significant differences in production rates in the various lake basins, although productivity in coves such as Morrison Pond increased to 170 g C/m²/yr (Geen, 1965). During most of the ice-free portion of the year, flagellated phytoplankters (15 μ maximum size) were the principal primary producers. Flagellates, diatoms (**Chaetoceros** sp.) and dinoflagellates (**Ceratium** sp.) were abundant during the winter months.

Zone 4: Gulf Shallow Regions

The Gulf shallow regions, for the purpose of this study, encompasses Prince Edward Island (P.E.I.) and includes the coastal area from the tip of Cape Breton, N.S., to and including Miramichi Bay, N.B. (Figure 1). The nature of the coast lines is depicted in Figure 2. Although this zone is not endowed with the same profusion of inlets and islands as the Atlantic shores of Nova Scotia, there are, with the exception of the east coast of Cape Breton, still many protected areas in the lee of enveloping shorelines.

On a broad scale, there is an east-to-west decreasing gradient in wave height commencing at the tip of Cape Breton, where the wave climate is most severe (Figure 3). Wind speeds follow roughly the same format (Figure 4). The smallest tides in the Gulf occur in the southwestern part (Figure 5). There is a major amphidromic point north of the zone in the vicinity of Magdalen Islands with another in Northumberland Strait (Anon., 1976). The average range is less than 1 m and spring tides seldom exceed 2 m. A slightly larger range occurs in the eastern half of Northumberland Strait.

Ryan thermograph records for the period 1979-1985 clearly indicate, from the many sampling stations in this zone, that the solar warming of the shallow and sometimes protected bodies of water in this zone result in significant areas recording temperatures in excess of 20°C during summer. The highest mean monthly temperature (22.9°C) was recorded in August in the Bideford River estuary. A low of 0.1°C was measured in February, also in P.E.I. However, lower temperatures are documented. Thomas (1970) measured sub-zero mean temperatures at a number of stations in the Bideford River estuary for the period 1964-1968. Minimum recordings at all depths ranged from −0.3°C to −0.8°. By contrast, mean-surface temperatures as high as 24°C were obtained in the summer. Those below 1 m ranged from 22°C to 23°C. Also, on the Bideford River (near the Ellerslie Biological Station, DFO), Uyeno (1966) reported a low of −0.2°C at all depths in April and a high of 23.8°C at the surface in August. The Gulf shallow regions present, therefore, a uniquely warm water zone during the summer months, and while we may already have noted that winter temperatures below zero can be experienced in the Bay of Fundy and the east coast of Nova Scotia, they are by no means so widespread or so long continued there as in the Gulf.

The generally low salinities in the Gulf of St. Lawrence arise from the freshwater runoff of the St. Lawrence River. In the open waters of the zone, the surface layer shows salinities (lowest in the summer) of 28 o/oo or less. Stephenson and Stephenson (1954) noted that minimum salinities observed in 1947 and 1949 along the north coast of P.E.I. were 25.2 o/oo and 27.7 o/oo. These values clearly reflect the effect of river discharge into the Gulf. In the estuaries, salinity may be considerably lower. For example, Thomas (1970) notes salinities at 1-1.5 m of 2 o/oo or less in summer at Bideford River. Salinities at over 2 m, however, never fell below 20 o/oo. Maximum salinities were proportional to depth and ranged from about 29 o/oo to 32 o/oo.

The normal mid-winter pattern of ice in the Gulf is one of relatively light ice, but with thicker more closely packed ice in the south. The ice spreads south and east until the Gulf and Cabot Strait are covered, reaching a maximum by the beginning of March (Figure 6). A great deal of the ice comes from the St. Lawrence River, and, in conjunction with the shore ice formed in situ, collect to form immense ice-fields. Ice formed along the shore of P.E.I. is heavily mixed with red clay and sand, and is unusually tough and often piles up into tough barriers (Stephenson and Stephenson, 1954). As elsewhere, the amount of ice formed in different winters varies considerably.

A comprehensive primary and secondary production study was undertaken throughout the Gulf of St. Lawrence from 1969 to 1972 as one of the Canadian contributions to the International Biological Program. Unfortunately, sampling stations in the southwestern Gulf, with the exception of a solitary station sporadically occupied in the eastern Northumberland Strait, did not cover the latter area. Carbon fixation rates for waters on the north side of P.E.I. and along the northwest portion of Cape Breton were reported (in mg C/m³/hr) as follows: April-May, 100-200; May-September, 51-100; September-November, < 50. Integrated chlorophyll values for the same period ranged from < 10 to 21-40 mg/m³ (Steven, 1974).

McIver (1972), in a comprehensive 1969-1970 study of primary and secondary production in Malpeque Bay, P.E.I., Bideford River (one of its tributaries) and nearby Gulf of St. Lawrence, reported respective highest phytoplankton productivity values of 16.11 (September), 66.89 (August) and 3.80 mg/C/m³/hr (September). Corresponding chlorophyll values were 3.959, 10.273 and 1.042 mg/m³. The lowest primary production rates for the same sites were 0.27, 2.10 and 0.041 mg C/m³/hr, respectively, with attendant chlorophyll concentrations of 0.615, 2.150 and 0.234 mg/m³. McIver speculated that the relatively low productivity levels in the centre of Malpeque Bay (not

much higher than those found offshore) were probably due to tidal flushing. He also noted the relative paucity of oysters and other molluscs in this area and the fact that primary productivity of the Bideford River peaks at the time when oyster larvae and other pelecypods and gastropod larvae are most abundant in the water.

An assessment of primary production was carried out at five stations, from June to October, 1969 and 1970, in the northwest basin of Northumberland Strait (Citarella, 1980). The waters were deemed eutrophic, with an integrated photosynthetic production rate of 1.876 g C/m³/day. Maximum values occurred at depths between 5 and 10 m.

Figure 7 shows concentrations of suspended particulate matter along the New Brunswick coast and the Northumberland Strait shore of P.E.I. Inshore stations at Chance and Tracadie (Figure 10 and Table 1) showed total particulate matter levels of 3.59 and 4.75 mg/L, respectively. Surface distribution of total particulate matter on the Gulf side of the Island, however, rarely exceeds 1 mg/L (d'Anglejan, 1970). Localized coastal areas affected by land drainage will necessarily experience greater concentrations varying with season, precipitation and weather-related stability of the water column.

There is no indication from the available literature that PSP poses a problem in the Gulf shallow regions environmental zone (Figure 8). However, as anticipated, many areas are subject to closure due to risks associated with bacteriological contamination (Figure 9).

Zone 5: Atlantic Coast of Newfoundland

The limits of this environmental zone lie roughly to the north of Bonavista Bay on the east coast of Newfoundland and to the west of Fortune Bay on the south coast of the Island (Figure 1). Basic shoreline classification is presented in Figure 11. Further details on coastal zone morphology and ecology of the northeast coast and of the Avalon and Burin Peninsula have been produced in separate reports by Hiscock and Maloney (1983) and Hiscock (1981), respectively. Shorelines throughout the study area offer a wealth of peninsulas, islets, bays, coves and minor indentations, which provide some measure of protection from wind and waves.

Again, the wave and wind climates are closely correlated and are generally the harshest of the five regions considered (Figures 3 and 4). The prevailing winds in Newfoundland are westerlies. Tides are typical of the Atlantic coast and appear comparable to those of Nova Scotia's Atlantic shores (Figure 5).

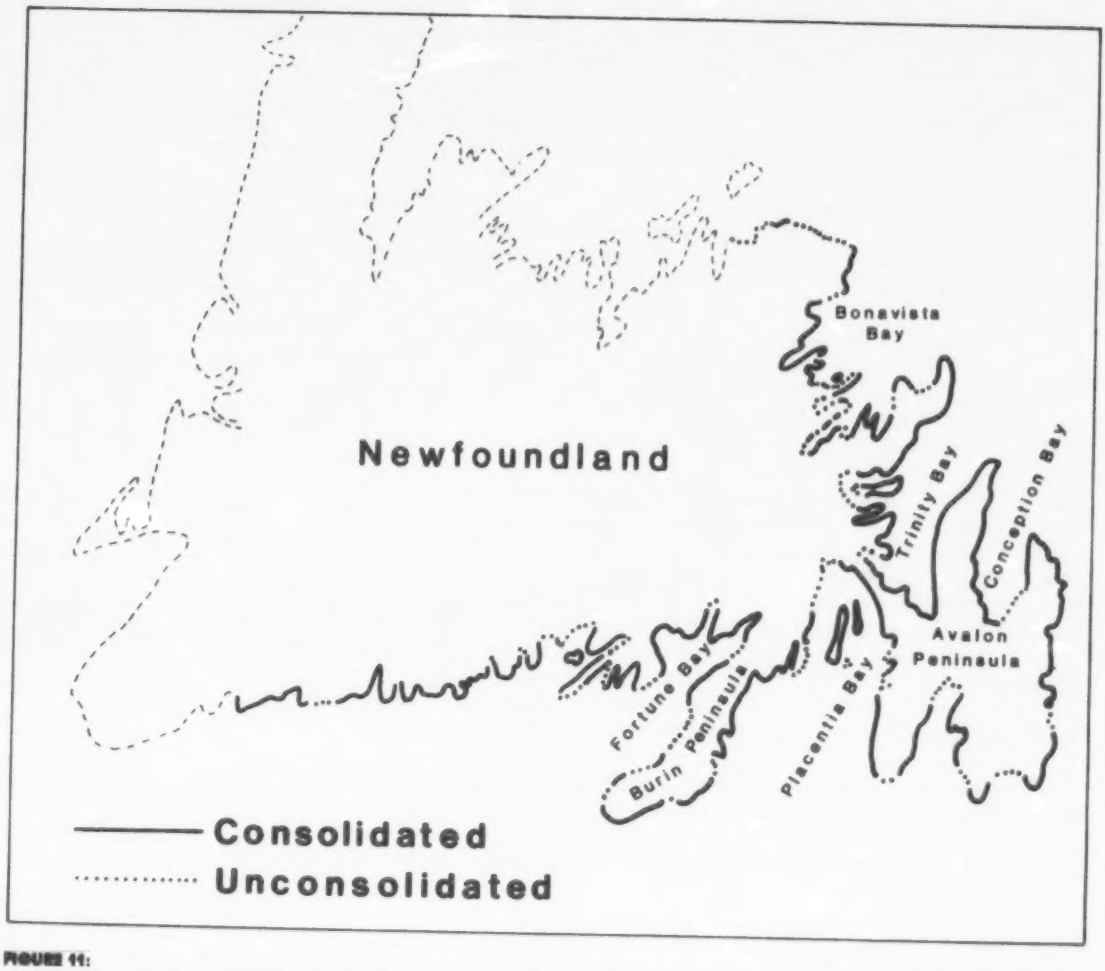


FIGURE 11:
COASTAL GEOMORPHOLOGY OF ATLANTIC SHORES OF NEWFOUNDLAND
(courtesy of Atlantic Geoscience Centre, Bedfor Institute of Oceanography).

Numerous Ryan thermograph recordings above 10 m are available from inshore sites for the period 1976-1985. The data show great variability in local temperature regimes. These vary from 0°C in February and March at a number of locations to a maximum of 20.5°C in August at Biscay Bay River and North East River, Placentia Bay. Temperatures in early summer varied from lows of 0°C at South Side Shag Rocks and 0.2°C at Gooseberry Cove and Garden Cove to a high of 9.7°C at Colinet on the Avalon Peninsula. There are also records of below zero temperatures (< -1°C) for surface coastal waters of Newfoundland (Douglas et al., 1986). Deibel and Turner (1985) reported a temperature of -1.1°C between 5 to 15 m in Logy Bay in January. On the whole, inshore temperatures during most of the year are colder than in other regions, reflecting its more northern position and the cooling effect of the Labrador current on its southward course.

Salinities are generally above 30 o/oo on the Newfoundland Shelf during the ice-free portion of the year and are comparable to the salinity over the Grand Banks, where it varies from a low of 31 o/oo in September/October to its winter-spring range of 32-32.5 o/oo (Scarratt, 1982). Limited available BIO current meter salinity data (April-June, 1980) revealed minimum and maximum values of 30.52 o/oo and 32.20 o/oo, respectively, in Fortune Bay.

Deibel and Turner (1955) recorded a salinity of 31.5 o/oo in Logy Bay in January, which is typical of the Bay throughout the year (Kendaris, 1980). Lower salinities are associated with sources of freshwater discharge from land.

Ice formation is a yearly event and affects most of this zone. By mid-February, migratory Arctic ice has advanced along the east coast flush with the northern edge of the Grand Bank, and, at its maximum extent in the spring (Figure 6), only that part of the south coast of Newfoundland between Point aux Basques and Burin Peninsula generally remains ice-free. The final retreat of the ice normally commences in March, and complete clearing occurs anytime from late April to the end of May (Scarratt, 1982).

There is a paucity of information on primary productivity, plankton biomass and suspended particulate matter concentrations from inshore waters of Newfoundland. Only very recently have some data been published. Low temperatures are not inhibitory to phytoplankton growth in the area, and the spring bloom in Newfoundland coastal waters is in progress during April and May at water temperatures between −1°C and 2°C (Pomeroy and Deibel, 1986). Primary productivity estimates made during spring bloom in Conception Bay ranged from 1.5 to 9.9 mg C/L/hr (K. Pauley, pers. comm., cited in Douglas et al., 1986). Phytoplankton production rate toward the end of the bloom in May in nearby waters (5 m) was measured at 0.83 μg C/L/hr (Douglas et al., 1986). Clorophyll observations between April and September in upper Conception Bay was, except for a short spring bloom in April, always less than 1 μg/L in the upper 10 m. Deibel and Turner (1985) reported phytoplankton concentrations on two sampling dates in May and one in January in Logy Bay of 1983, 1738 and 3506 cells/mL, respectively. **Nitzschia** spp. dominated in January; flagellates, monads and **Chrysophycea** in May.

Suspended particulate matter data for inshore sites are scarce, but results from sediment traps in upper Conception Bay, typical of large bays in the environmental zone, suggest that coastal waters are relatively clear. There is little terrigenous or anthropogenic input of particulate matter in this Bay (Thompson et al., 1986).

Until recently, paralytic shellfish poisoning was not identified in Newfoundland. The first recorded case occurred in 1982 from blue mussels harvested in Conception Bay (White and White, 1985). Mussels at two locations on the south coast of the island and at one location on the north coast were also found to contain toxins at this time (Figure 8). Mud samples from Conception Bay revealed the presence of **Gonyaulax excavata** cysts, which proved to be toxic. Because of the simultaneous contamination in separate locations in Newfoundland in 1982, White and White (1985) suspected that the causative organism has been in the region for years, but only occasionally are meteorological and hydrographic conditions suitable for pronounced blooms and shellfish toxicity. In 1983, the south and east coast locations registered low toxicity levels in mussels, but only from the latter in 1984.

Bacterial contamination of inshore water appears not to be a widespread phenomenon in the Newfoundland environmental zone (although absence of the problem may simply reflect the lack of an important commercial harvest of bivalves as an indicator). However, a 1980 survey at Little Bay, Burin Peninsula, did disclose unacceptable faecal counts and a closure was implemented, albeit never gazetted, in 1983 (J. Roberts, pers. comm.).

BIOLOGICAL REQUIREMENTS OF AQUACULTURE SPECIES

The commercial viability of an aquaculture enterprise is determined largely by the biological performance of the species being cultured. Environmental factors may play a major role in this. Interaction with the environment

can take many forms; extremes of temperature and salinity may exceed limits for survival; critical temperature thresholds for spawning may not be reached or the period of necessary high temperatures may be too short to allow successful reproduction; either temperature or salinity may be outside the most efficient range for growth; in the case of filter-feeding molluscs, feed densities may be too low to allow cost effective rearing technology.

Table 2 presents the limits of the key environmental factors that influence the survival, growth and reproductive success of the important salmonids and molluscan species in the Atlantic region.

The biological requirements of the commercially important molluscan species are summarized below:

- **the American Oyster (Crassostrea virginicaa)** is a sub-tropical species requiring relative high water temperatures for both reproduction and growth. It is, however, a very hardy species, able to survive long periods at low winter temperatures, and well adapted to low salinity estuarine conditions. This species is well suited to the extreme seasonal variations of the shallow inlets and embayments of the Gulf of St. Lawrence, its natural range.
- **the European Oyster (Ostrea edulis)** is essentially a temperate zone species, suited to lower estuary and open ocean conditions, sensitive to both the lower temperatures and salinities of the habitat of the native oyster. It is capable of performing well in the lower temperatures of the Atlantic coast of Nova Scotia.
- **The Blue Mussel (Mytilus edulis)** is a native sub-arctic species, naturally distributed throughout the region. It is not as tolerant of, or as productive in, the high temperatures and low salinities of the more extreme Gulf of St. Lawrence estuarine conditions, but performs well in the more oceanic conditions of eastern P.E.I. and southern Nova Scotia.

The two salmonid species, **Atlantic salmon (Salmo salar)** and **rainbow trout (Salmo gairdneri)** share the most significant biological requirements determining their successful culture, a lower lethal temperature limit which is reached throughout most of the region during winter. This restricts their culture in areas such as the Gulf of St. Lawrence to seasonal operations and allows multi-season culture only in parts of the Bay of Fundy coast of New Brunswick where tidal and oceanographic mixing allows overwintering in the south of Nova Scotia, and in Newfoundland where under ice technologies are being developed.

TABLE 2:

RELATIONSHIP OF IMPORTANT MARICULTURE SPECIES TO LIMITING ENVIRONMENTAL FACTORS

	MOLLUSCS		
Temperature	**American Oyster**	**European Oyster**	**Blue Mussel**
Survival	−2 to 40°C	0 to 35°C	−2 to 30°C
Activity	3 to 35°C	4 to 30°C	3 to 30°C
Growth range	5 to 30°C	5 to 25°C	5 to 25°C
(optimum)	15 to 20°C	10 to 15°C	10 to 20°C
Spawning	20°C+	15°C+	12°C+
Salinity			
Survival	10 to 45 o/oo	20 — 35+ o/oo	15 to 35+ o/oo
	SALMONIDS		
Temperature	**Atlantic Salmon**	**Rainbow Trout**	
Lower lethal	−0.7°C	−0.7°C	
Growth range	5 to 20°C	2 — 25°C	
(optimum)	13 to 16°C	15 — 18°C	

ENVIRONMENTAL CONSTRAINTS ON AQUACULTURE

The marine environment in the Atlantic region is a complex combination of biological, physical and chemical factors which determines and effectively limits the distribution and scope of aquaculture development in the region. Economic success and development will be predicated on the suitability of the environment and its attendant water resources. Taking into account the major constraints that influence the development of marine aquaculture in Atlantic Canada, geographic limits have been identified in Figure 12 for viable commercial operations. These suggested geographic limits for potentially viable commercial operations are, at this stage of the development and knowledge of relevant parameters, necessarily tentative and are subject to modification by such factors as technological development and market price.

The distribution of successful aquacultural enterprises in Atlantic Canada will be determined by the following limitations:

1. Limits on Survival of the Species:

In the preceeding section, the major environmental parameters have been described for those areas where commercial aquaculture development has shown the greatest promise. Environmental extremes of water temperature and salinity are the main constraints for aquaculture development. Although technology can often overcome such factors as temperature, the additional expenditures involved can affect the relative competitiveness of the product in the market place. Examples where limits on survival have been critical include the salmonid seacage culture in the Bay of Fundy, which is primarily related to acceptable overwintering sea temperatures afforded by dynamic tides and currents. For the culture of the American oyster, water quality, nutrients and substrate are the key determinants to survival.

2. Limits of Essential Biological Parameters:

A biological parameter of major significance is reproductive success and the capacity to breed cultured stocks. Aquaculture operations should strive to become self-sustaining with respect to broodstock and environmental constraints that do not allow completion of the full life cycle may well restrict commercial viability. Problems created by the non-maturation or release of gametes in an aquaculture species maintained in a constraining environment, may be overcome through the importation of seedstock from other areas. This might even have commercial advantages if the import of the seed to the culture site is practical.

In certain cases, more severe environmental conditions might well affect biological processes to commercial advantage. For example, the delayed maturation observed in Atlantic salmon held overwinter in sea cages in the Bay of Fundy, in contrast to fish not exposed to such conditions, would indicate that cold (but not lethal) winter sea temperatures are a positive factor in terms of growth as well as control of maturation.

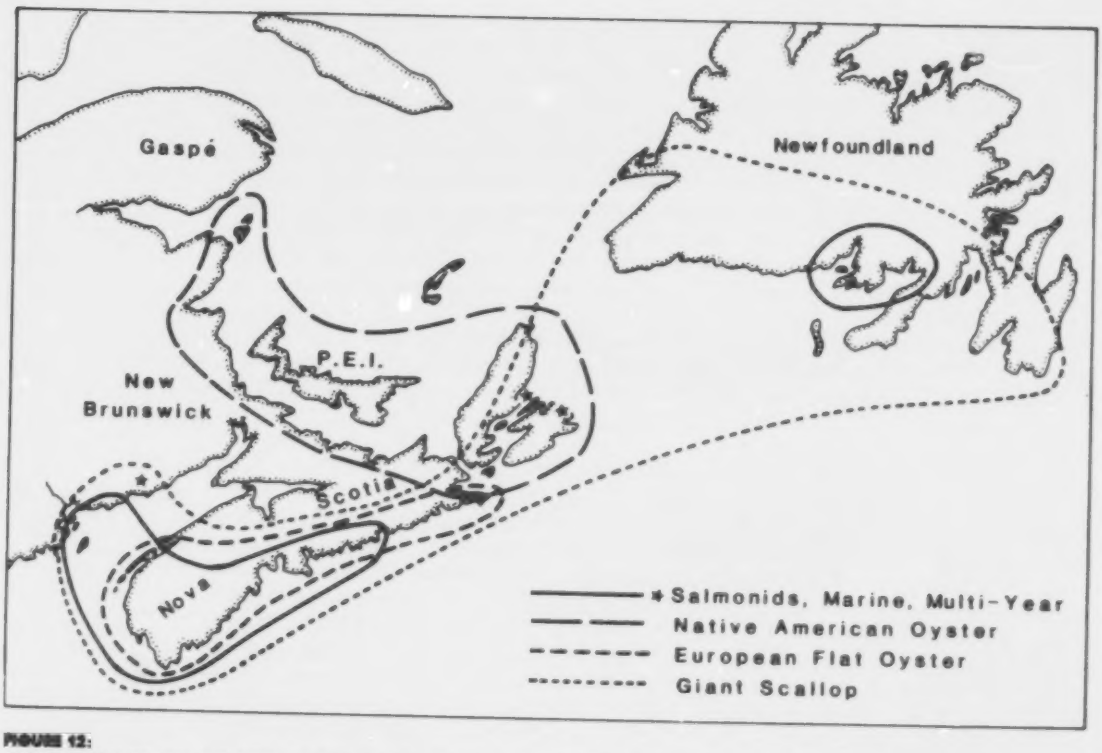


FIGURE 12:
GEOGRAPHIC LIMITS FOR POTENTIALLY VIABLE COMMERCIAL OPERATIONS FOR MARINE SPECIES OF IMPORTANCE FOR AQUACULTURE DEVELOPMENT. THE LIMITS FOR LOBSTER AND MUSSEL INCLUDE ALL FIVE AQUACULTURE ENVIRONMENTAL ZONES IN THE REGION.

3. Limits on the Application of Technology:

The marine environment of Atlantic Canada has often been described as harsh with dramatic oceanographic and climatic processes often acting in combination and causing severe marine environmental conditions along the coastline. Under such conditions, all aquaculture operations, with the possible exception of some shallow, bottom-culture molluscan activities, require varying degrees of protection from the prevailing winds, tides, currents, waves and ice. Exposure to wave action and ice cover perhaps predominate this list of constraints. The nature of the shoreline and the presence of predominantly consolidated or non-consolidated material, is another index of coastal environmental conditions.

The first aquaculture developments in the marine environment will be laying claim and occupying those sites where reasonable protection is afforded by geographic features such as coves, inlets and islands. As these natural areas are utilized, further development will be moved to less-protected areas and, under these circumstances, the design and survival of structures placed in areas of greater environmental risk will become more prevalent. The technology for strengthened platforms, mooring systems, and the development of improved methods to cope with aquaculture operations in exposed marine environments and to withstand storm conditions is already an important requirement. The adaptation to the hostile marine environment has also focussed attention on the development of shore-based aquaculture technologies.

The advantages of shore-based facilities such as protection from sea condition, ease of access, better control of growing conditions may well

outweigh the obvious disadvantages of the higher capitalization required for shore-based facilities and the cost of pumping seawater. If seawater for shore-based facilities can be obtained from sand pointing (i.e. the use of drilled wells in the marine environment that yield seawater, generally warmer and less saline than ambient seawater) or from related geothermal saltwater extraction techniques, the advantages, in terms of improved water quality and temperature alone, might prove of economic advantage. The technology to condition and recycle "used" or "once-through" seawater has been steadily developing. The cost of recirculating conditioned water within a facility with limited make-up water (5-10%) and the related thermal advantages is clearly less than pumping all the water from a submerged seawater intake.

There have been suggestions to utilize the extreme tidal conditions in the Bay of Fundy to obtain seawater for shorebased activities. Seawater would be collected in reservoirs at high tide and this water would be gravity fed to shorebased tanks as the tide recedes.

Perhaps the most common approach to coping with the limits imposed by the marine environment has been to establish aquaculture facilities in proximity to the thermoelectric production and utilizing the thermal effluents of such operations to heat the water of aquaculture units. Proposals for such applications are at various stages of planning, design and assessment, principally in Nova Scotia, New Brunswick and Newfoundland. The availability of heated seawater at low cost and the resultant enhanced growth rates make such proposals enticing; the technological difficulties do not appear insurmountable. Such approaches will allow the expansion of commercial aquaculture in areas of Atlantic Canada, where the local marine environment and water resource conditions would otherwise have been limiting. These opportunities, nevertheless, are by their nature site specific and thus limited; in some cases, the applications are technically difficult; in all cases, they tend to be extremely costly requiring major investment and capitalization.

4. Limits of Economic Viability

At present, aquaculture production in Canada is based on the luxury seafood/fish sector of the food industry. The sale price of the product must be sufficient to allow for production costs generally higher than those encountered in the traditional capture fishery and still allow for profit and reinvestment. Aquaculture production in Atlantic Canada shows this trend with salmonids, oyster, mussel and lobster as the major commercial items.

Economic viability of aquaculture in the region is directly dependent on the marine environment and its influence on the survival and growth rate of the cultured species. To maintain a competitive position with the increasing levels of production further south and in Europe, aquaculture production costs will have to be continually reduced through efficiencies gained by technology and increasing scale of operations. Supportive government policy in technology development, infrastructure, and international marketing will be essential for competitive survival. Transportation costs for both supplies and product will remain significant factors in Atlantic Canada because of its relative remoteness and, as the industry expands, special considerations might well be required to facilitate the shipment of fresh product to distant markets in North America and overseas.

Within individual aquaculture production units, the question of scale for an economically viable operation becomes important, both as a matter of regulation and the orderly development of an industry operating within a "commons" involving other uses of the marine environment, as well as from strict business economics. At what point does the principal of diminishing returns set in and size of operation become at risk for a series of husbandry, harvesting and security cost-related reasons. Another constraint, related to

environmental factors, is the socioeconomic implications on aquaculture development. What are the relative benefits to a region from a large number of small, individually owned production units in contrast with a few larger, "corporation" sized entities? Economic development in more remote areas might not always be able to be based on sound and economically viable reasons and this could have a serious effect on our international competitiveness. Such tradeoffs continually plague Atlantic Canada in many economic development sectors. In aquaculture, with the strong and increasing international market pressures, it will be essential to build an economically sound industry with low production cost as the principal criterion for a successful enterprise.

5. Limits Imposed by Public Health Factors:

The use of the marine environment for a broad range of industrial, transportation, energy, and municipal activities can have severe implications on aquaculture developments in the marine environment. Major industrial activities with attendant sources of water pollution and potential release of toxic chemicals can deny the location of aquaculture sites anywhere near the operational site. In the Maritimes, the extensive closure of shellfish harvesting areas poses a severe environmental constraint, especially on molluscan aquaculture. There are, however, well-established procedures for cleansing of shellfish stock either by placement of contaminated shellstock into special depuration facilities or by the relay of shellstock from contaminated areas to "clean" areas for several months prior to harvesting. A variation of this approach, the "basket relay," involves the harvesting of shellstock from a "closed" shellfish harvesting area and holding the shellfish in containers suspended in a "clean" water column for a prescribed time before marketing. These procedures overcome an environmental constraint; they do add to the production costs, making it more difficult to compete with shellstock harvested without these overheads.

The environmental constraint imposed by the presence of the dinoflagellate **Gonyaulax excavata**, the organism responsible for paralytic shellfish poisoning (PSP), has been described earlier. The PSP factor cannot be effectively treated by depuration. Environmental constraints imposed by PSP seem to be expanding in recent years with occurrences in other parts of Atlantic Canada. With the exception of the aquaculture of the giant scallop, **Placopecten magellanicus**, PSP is an environmental factor of prime importance in molluscan aquaculture in the region.

SUMMATION:

The major aquaculture producing areas of the Atlantic region have been divided into five aquaculture environmental zones. Each of these zones has distinctive environmental characteristics which tend to be of advantage to one species over another. When the geographic limits for potentially viable commercial species are considered, limits which take into account the essential biological requirements of the species of importance to aquaculture, the utilization and potential of the marine water resources for future aquaculture development can be more clearly determined.

A review of the data base available on the marine environment and water resources relevant to aquaculture has been presented. There are many sources of information on the marine environment of the Atlantic region, however, those which are useful to aquaculture development are limited. Environmental studies conducted in support of an aquaculture development, for example the Kennebecasis Bay salmonid aquaculture project, or the oyster research programs carried out at Ellerslie, P.E.I., provide good background on the seasonal nature of the water resource as well as estimates of biological productivity. More such site specific environmental studies are clearly required.

At existing aquaculture operations, measurements of environmental conditions are routinely taken. This information is generally difficult to access, and new systems are required to make better use of this extensive source of environmental data of direct relevance to marine aquaculture. Other sources of environmental data, from routine gouvernmental surveys are not usually relevant to the information needs for aquaculture development. There is, therefore, a strong need for comprehensive environmental surveys and monitoring of marine water resources in areas of importance to aquaculture.

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APPROCHE NUTRITIONNELLE DES PROBLÈMES D'ÉLEVAGE DES SALMONIDÉS EN EAU FROIDE

par S. Kaushik

INTRODUCTION

Dans le milieu naturel, l'alimentation des Salmonidés est essentiellement de nature protéique. En effet, les invertébrés qui constituent la base de cette alimentation en milieu naturel renferment de 35 à 70% de protéines, de 10 à 30% de matières grasses, de 3 à 25% de minéraux avec une très faible proportion de glucides. Cette composition rend assez bien compte des besoins alimentaires de ces poissons, de leur capacité à utiliser les différents nutriments et de la composition des aliments artificiels utilisés pour leur élevage intensif.

L'alimentation et l'élevage en milieu aquatique des animaux, qui au cours de leur vie, présentent une gamme de poids très large (100 mg à quelques kilogrammes) soulèvent un certain nombre de problèmes spécifiques: modes de présentation et modalités de distribution des aliments, maîtrise de la qualité du milieu. Les poissons étant des animaux poécilothermes (à sang froid), la température de l'eau est un facteur de contrôle qui agit sur les besoins alimentaires et gouverne l'ensemble des mécanismes métaboliques intervenant dans l'utilisation des aliments (Brett, 1979).

Les réponses à une modification de la température sont variables selon qu'il s'agit de fluctuations périodiques ou de différences du niveau thermique (Threader et Houston, 1983). Dans le milieu naturel, les poissons soumis aux fluctuations thermiques peuvent réagir par des réponses d'ordre comportemental. Dans des conditions d'élevage intensif, on note une modification du comportement alimentaire et de la vitesse de croissance.

Cette capacité d'adaptation à la température ambiante a ses limites. En effet, pour chaque espèce, la vitesse de croissance ou l'efficacité d'utilisation alimentaire est maximale à une gamme de températures correspondant à son préférendum thermique. Pour ce qui concerne les Salmonidés, les températures optimales se situent entre 12 et 18°C.

La nature poécilothermique des poissons leur confère un certain nombre de particularités. Contrairement aux mammifères qui, pour maintenir leur température corporelle constante ont des dépenses énergétiques élevées, les poissons ont des besoins énergétiques d'entretien très faibles. Ces besoins sont encore diminués lorsque la température baisse (Tableau 1). C'est ainsi qu'aux températures très basses, les poissons sont capables de survivre en diminuant leurs activités métaboliques, ce qui se traduit par une réduction de leurs besoins en nourriture et en oxygène.

TABLEAU 1:

COMPARAISON DES DÉPENSES ÉNERGÉTIQUES D'ENTRETIEN ENTRE HOMÉOTHERMES ET POÉCILOTHERMES ET INFLUENCE DE LA TEMPÉRATURE CHEZ CES DERNIERS.

Espèce	Poids vif (g)	Temp. (°C)	Énergie (kJ/kg 0,75/jour)
Truite arc-en-ciel	50-100	7.5	11
		10	24
		15	29
		20	33
Carpe	40-90	23	54
Poulet	1500	Neutralité thermique	355
Rat	130	22	552
	80-120	30	380

BESOINS ALIMENTAIRES ET RECOMMANDATIONS

Il convient d'abord de distinguer besoins alimentaires et modes de couverture de ces besoins. Dans les élevages intensifs, l'alimentation artificielle doit permettre de satisfaire les besoins de tous les nutriments indispensables aux survie, croissance et reproduction. Dans les grandes lignes, les besoins nutritionnels en une quarantaine d'éléments nutritifs (protéine, énergie, acides aminés, acides gras, minéraux et vitamines) sont établis pour les poissons d'eaux froides (NRC, 1981). Mais lorsque l'on y regarde de près, les données sur les effets de la température (le facteur ubiquiteux, par excellence) sur ces besoins sont loin d'être complètes. Nous essaierons cependant dans ce qui suit d'analyser les informations disponibles sur l'alimentation des Salmonidés élevés à des températures plus basses qu'optimales.

ALIMENTATION PROTÉIQUE

Les premiers travaux de Delong **et al** (1958) chez le saumon quinnat (chinook) ont indiqué une augmentation du besoin protéique en fonction de la température (de 40% à 7°C à 50% à 15°C). POSSOMPES (1973) a étudié les besoins protéiques de la Truite arc-en-ciel à deux températures: 10 et 18°C. Il n'a pas pu mettre en évidence une différence dans les besoins quantitatifs. Les travaux effectués ultérieurement, également chez la Truite à différentes températures (9, 12, 15 et 18°C) par Slinger **et al** (1977) et Cho et Slinger (1978) ont montré que si la vitesse de croissance augmente avec la température, les besoins protéiques ne varient pas. Entre 35 et 55% des protéines dans les rations, aucune différence n'a été observée. Ces besoins protéiques sont exprimés en pourcentage de la ration et non en absolu (par exemple, en g Protéines/kg du Poids vif/jour). Si le besoin protéique absolu augmente avec la température, l'augmentation de la prise alimentaire permet de satisfaire ces besoins même avec des régimes à 35% de protéines.

Les données actuelles sur les besoins quantitatifs en acides aminés essentiels des Salmonidés (voir NRC, 1981) ne permettent pas de se prononcer sur une influence éventuelle de la température. Nos propres travaux sur le besoin en un acide aminé essentiel, l'arginine, indiquent qu'il peut y avoir une influence de la température sur ce besoin: le besoin en arginine légèrement plus élevé à 12°C comparé à 18°C (Kaushik, 1977).

En ce qui concerne l'absorption des acides aminés en fonction de la température, tous les acides aminés essentiels ne semblent pas agir de la même façon (Kaushik et Luquet, 1978). D'autre part, au niveau de la synthèse protéique, l'influence de la température est variable selon les tissus (Tableau 2).

TABLEAU 2:

SYNTHÈSE ET DÉPÔT DES PROTÉINES CHEZ LA TRUITE ACCLIMATÉE À 10 ET 18°C. (d'après Fauconneau et Arnal, 1985)

		Foie	Tube digestif	Muscle	Truite entière
10°C	Synthèse (1)	42	153	167	500
	Dépôt (1)	2	17	87	150
	Efficacité (2)	5	11	52	30
18°C	Synthèse	125	347	195	886
	Dépôt	38	28	140	239
	Efficacité	3	8	72	27

(1) mg/jour
(2) Protéines déposées/protéines synthétisées

La croissance des poissons traduit la différence entre l'anabolisme (synthèse) et le catabolisme (dégradation des protéines). Une élévation thermique améliore l'efficacité du dépôt protéique au niveau du muscle (52% à

10°C et 72% à 18°C), mais pas au niveau du poisson entier. Actuellement, nous ne disposons pas de données permettant de définir, au moins d'un point de vue qualitatif, les besoins spécifiques des différents tissus. Tout porte à croire qu'en ce qui concerne le métabolisme protéique, le facteur thermique intervient par le biais des modifications de la prise alimentaire.

ALIMENTATION ÉNERGÉTIQUE

La régulation de la consommation volontaire (prise de nourriture) a pour but de satisfaire les besoins énergétiques du poisson. Le besoin énergétique pour l'entretien est faible (Tableau 1) et celui pour la croissance est de l'ordre de 17 MJ/kg de gain de poids. Dans la mesure où une partie des protéines alimentaires sert aussi à la couverture de ces besoins, la notion du rapport protéine: énergie a une signification particulière dans l'alimentation des poissons. De cette notion découlent également les progrès réalisés dans le domaine de l'épargne protéique grâce à l'incorporation d'autres sources énergétiques facilement digestibles par les poissons.

Si l'on a quelques indications quant à l'influence de l'âge sur la participation des protéines au métabolisme énergétique (Dabrowski, 1987), les données disponibles ne montrent pas d'effets significatifs de la température sur cette contribution protéique. Le rapport optimal conseillé est de l'ordre de 20 à 25g Protéine/MJ d'énergie digestible (Cho et Kaushik, 1985).

La digestibilité de l'énergie ne varie pas avec la température; l'utilisation de cette énergie digestible pour la production est par contre fortement influencée. Ainsi, l'énergie disponible pour la croissance n'est que de 44% de l'énergie digestible à 7,5°C et est de 58% à 20°C (Tableau 3).

TABLEAU 3:

VARIATIONS DE L'INGESTION VOLONTAIRE ET DE L'UTILISATION DE L'ÉNERGIE INGÉRÉE EN FONCTION DE LA TEMPÉRATURE.
(d'après Cho et Slinger, 1979)

Température (°C)	7,5	10	15	20
Ingestion (1)	67	136	244	304
Utilisation (2)				
Pertes fécales	22	22	20	20
Pertes métaboliques	8	8	8	8
Extra chaleur	15	10	9	11
Énergie nette	55	60	63	61
Dépenses d'entretien	21	22	21	15
Production	34	38	42	46

(1) en kJ/kg/jour
(2) en % de l'énergie ingérée

Chez la plupart des animaux, une augmentation de la température de 10°C conduit à une augmentation des taux métaboliques par un facteur de 2 (Q10=2). Selon ce schéma, un poisson élevé à 15°C aura un besoin énergétique deux fois supérieur à celui à 5°C. Les travaux de Smith **et al** (1978) ont montré que les besoins énergétiques d'entretien de différentes espèces de Salmonidés ne varient pas de la même façon en fonction de la température. Les valeurs de Q10 ainsi trouvées sont 1,37, 1,5, 1,8 et 1,9 pour le saumon atlantique, la truite arc-en-ciel, la truite du lac et le saumon de fontaine.

ALIMENTATION LIPIDIQUE

L'incorporation de la matière grasse dans les aliments a pour but: 1. de satisfaire les besoins en acides gras essentiels (AGE) à la constitution et au

bon fonctionnement des membranes cellulaires, 2. d'augmenter l'apport énergétique.

Contrairement aux mammifères qui ont un besoin en acide linoléique (arachidonique), les acides gras essentiels des poissons sont des acides gras de la série n-3: acide linolénique (1% de la ration), ou acide eicosopentacnoique (0,5%) ou acide docosohexaenoique (0,5%). Les deux derniers acides gras sont indispensables pour les poissons marins et sont plus efficaces que le premier même en eau douce.

Les poissons ont en général une teneur en acides gras polyinsaturés (AGPI) de la série n-3 plus élevée que les animaux terrestres et leurs besoins en acides gras rendent bien compte de leur composition corporelle. Les poissons marins ont des teneurs en ces acides gras plus élevées que ceux d'eau douce; les rapports moyens en n-6/n-3 sont de 0,16 et 0,37 en eau de mer et en eau douce respectivement. Ces rapports diminuent également avec une baisse de la température. Si l'on considère que la composition corporelle en acides gras fournit une indication du besoin, on peut envisager une augmentation du besoin en acides gras de la série n-3 dans les eaux froides.

Le choix des matières grasses sera donc fonction de leur teneur en ces acides gras. Par exemple, ces besoins peuvent être couverts par l'huile de soja à un taux de 10% dans le régime ou par seulement 4% d'huile de poissons.

Une fois ces apports minima réalisés, tout apport supplémentaire en matières grasses aura pour résultat l'augmentation de l'énergie digestible de l'aliment. En effet, quelle que soit l'origine de ces matières grasses (animale ou végétale), la digestibilité n'est pas affectée tant que le point de fusion reste faible. La température de l'eau (entre 3 et 11°C) a peu d'effets sur la digestibilité des matières grasses (Tableau 4).

TABLEAU 4:

INFLUENCE DE LA QUALITÉ DE L'HUILE SUR LA DIGESTIBILITÉ DES LIPIDES À DEUX TEMPÉRATURES.

Nature de l'huile	Point de fusion (°C)	Digestibilité	
		3°C	11°C
Soja	−8	87,9	89,2
Foie de morue	−3	90,6	87,2
Capelan	10	85,8	84,8
Capelan hydrogénée	21	74,6	75,2
Capelan hydrogénée	33	68,8	69,5
Capelan hydrogénée	41	46,4	49,0

Les travaux de Cho (1979) ont montré qu'à 7,5°C, les performances zootechniques sont inférieures à celles notées à 12,5°C ou à 17,5°C. À chacune de ces trois températures, lorsque l'on augmente le taux d'incorporation des lipides de 13 à 18% de la ration, on observe une amélioration de la croissance et de l'indice de consommation. Cette amélioration par des apports supplémentaires en lipides est cependant faible à 7,5°C. Le rapport optimal entre protéines et lipides à retenir dans les aliments pour poissons est de 36:18 et ne varie pas avec la température.

ALIMENTATION GLUCIDIQUE

Dans le milieu naturel, les Salmonidés reçoivent une alimentation dépourvue de glucides. De ce fait, ils sont peu adaptés à l'utilisation, tant au niveau digestif qu'au niveau métabolique, des glucides. La digestibilité des glucides varie en fonction de la complexité des molécules: l'amidon cru est très peu digéré (20-40%) tandis que les sucres simples comme le glucose sont très -

bien digérés (99%). La faiblesse de la digestion de l'amidon, qui peut parfois représenter 25 à 30% des ingrédients d'un aliment, est dûe à un déficit du tube digestif en amylase.

Une amélioration de l'utilisation digestive peut être obtenue par l'incorporation dans les aliments de l'amidon ou mieux encore des céréales entières ayant subi des traitements hydrothermiques appropriés (e.g. extrusion). Ceci permet d'augmenter l'énergie digestible et aussi de l'énergie métabolisable.

En effet, l'épargne protéique par l'utilisation des glucides digestibles passe aussi par une diminution des pertes métaboliques ammoniacales. Ainsi, Kaushik et Oliva-Teles (1986) ont montré que l'incorporation de l'amidon gélatinisé au lieu de l'amidon cru permet d'augmenter l'énergie métabolisable de l'aliment avec une rétention protéique supérieure. Des travaux plus récents ont montré que l'emploi de céréales entières extrudées dans les aliments pour truite est, des points de vue pratique et économique, très intéressant (Tableau 5).

L'efficacité de la digestion d'amidon (cru ou traité) diminue par contre lorsque les taux d'incorporation sont élevés (Bergot, 1979). Pour les poissons carnivores comme les Salmonidés, il est raisonnable de ne pas dépasser le seuil d'incorporation de l'ordre de 25% en glucides digestibles. En effet, ces poissons ont quelques difficultés pour bien utiliser les glucides absorbés: mauvaise régulation de l'hyperglycémie, faible contrôle insulinique. Une augmentation de la température du milieu ne semble pas améliorer la mauvaise utilisation métabolique des glucides.

TABLEAU 5:
UTILISATION DES CÉRÉALES ENTIÈRES EXTRUDÉES DANS L'ALIMENT POUR TRUITE (18°C).

	Amidon cru	Amidons extrudés		Céréales extrudées	
		Maïs	Blé	Maïs	Blé
Grain (1)	308	345	339	361	275
I.C. (2)	1.31	1.18	1.22	1.15	1.21
C.E.P. (3)	2,13	2.13	2,02	2,10	1,94

1. en % du poids initial (28g, 15 semaines)
2. Indice de Consommation = Quantité ingérée/Gain de poids
3. Coefficient d'Efficacité Protéique = Gain de poids/Protéines ingérées.

INGESTION — DIGESTION — ABSORPTION

Comme les besoins énergétiques pour l'entretien et la capacité de croissance sont faibles aux basses températures, il convient de porter la plus grande attention aux taux de nourrissage, en tenant surtout compte de la densité énergétique (énergie digestible) de l'aliment.

Récemment, Storebakken (1986) a montré qu'aux températures inférieures à 13°C, les variations du taux de rationnement ont peu d'effets sur la croissance du saumon atlantique. À ces températures, la croissance des alevins nourris aux taux de 0,5 ou 1% du poids vif n'est pas très différente de ceux nourris même à 3,25% du poids vif par jour. Aux températures basses, un excès d'aliments n'apporte pas un gain supplémentaire, mais peut conduire à une plus grande pollution du milieu dûe à la mauvaise utilisation de l'aliment distribué.

Au niveau digestif, les activités enzymatiques ainsi que la vitesse du transit intestinal augmentent avec la température du milieu (Fänge et Groves, 1979). Par exemple, à une température de 5°C, la durée du transit dépasse 72 heures, alors qu'à 20°C, elle n'est que de 16 heures. La diminution du temps de contact entre les nutriments, les enzymes et les sites d'absorption dûe à

une élévation thermique n'affecte pas cependant la digestibilité des nutriments. La prise de nourriture ainsi que l'activité des enzymes digestives sont augmentées compensant ainsi l'accélération du transit des nutriments à travers le tube digestif.

Quant à l'excrétion de l'ammoniaque (le produit final de la dégradation des protéines), l'excrétion endogène qui reflète le catabolisme des protéines corporelles augmente avec la température (Kaushik, 1980). Par contre, les pertes fécales ou métaboliques d'origine alimentaire ne varient pas.

En ce qui concerne la composition corporelle, il existe une relation assez linéaire entre la vitesse de croissance et le dépôt lipidique chez l'ensemble des Salmonidés. De ce fait au moins, les taux lipidiques des poissons élevés dans les eaux froides sont plus faibles. Le facteur de condition (rapport poids/longueur 3) qui traduit l'embonpoint du poisson varie également (Dwyer **et al**, 1983): chez le saumon de fontaine (**Salvelinus Fontinalis**), on observe des valeurs de 0,8 et 1,2 à 4 et 19°C respectivement.

AMÉLIORATION DES PERFORMANCES ZOOTECHNIQUES

De nombreux travaux effectués au cours des dernières années laissent prévoir la possibilité de l'amélioration de la croissance par l'emploi de certaines hormones: stéroïdienne, thyroïdienne ou peptidique (Donaldson **et al**, 1979; Matty, 1986). Dans le tableau 6 sont présentées quelques unes des hormones stéroïdiennes qui ont pu être incorporées dans les aliments pour l'amélioration de la croissance et de l'indice de consommation de divers Salmonidés. Il semble cependant admis que ces effets sont plus significatifs dans une gamme de températures allant de 9 à 15°C (McBride **et al**, 1982). Quant à l'emploi des hormones thyroïdiennes, la tri-iodo-thysonine (T3), à un taux ne dépassant pas 20 mg/kg d'aliment, permet d'augmenter la consommation volontaire et aussi de diminuer l'indice. Ceci est d'autant plus intéressant que l'emploi de T3 semble permettre une meilleure utilisation des glucides alimentaires par la truite arc-en-ciel (Fagerlund **et al**, 1984).

En ce qui concerne l'hormone de croissance, si les effets bénéfiques sont démontrés, les modes d'administration (injection hebdomadaire, implants) actuellement utilisés ne peuvent être mis en oeuvre à l'échelle d'une pisciculture. D'autre part, les aspects économiques, biologiques (consommation, croissance, rémanence) et légaux doivent être pris en compte avant de promouvoir ces types d'interventions. Pour une amélioration de la production, il est possible d'intervenir à différents niveaux de l'utilisation d'un aliment.

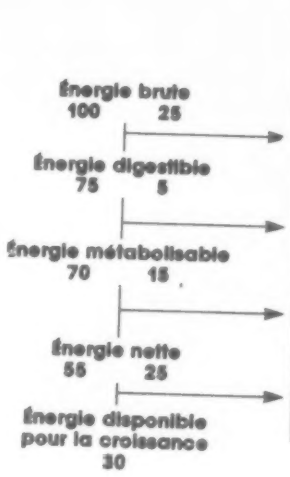
La diminution des diverses pertes contribue à améliorer les performances et à maintenir la qualité du milieu (Figure 1). S'il est connu que la farine de poissons constitue une matière première de choix et qu'il a été, jusqu'à l'heure, pratiquement impossible de lui trouver un produit de substitution économique et de qualité équivalente, on peut s'interroger sur le ou les principes qui lui confèrent cette supériorité pour la salmoniculture. Dans ces conditions, la qualité des matières premières est le premier critère de choix. Une amélioration de la performance par l'emploi des « facteurs de croissance » ne peut intervenir que lorsque l'aliment lui-même est entièrement satisfaisant.

TABLEAU 6:

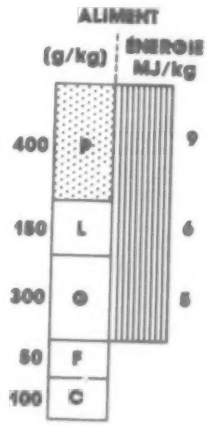
QUELQUES HORMONES STÉROÏDIENNES INCORPORÉES DANS LES ALIMENTS POUR AMÉLIORER LA PERFORMANCE ZOOTECHNIQUE DES SALMONIDÉS. (Températures inférieures à 13°C)

Hormone	Doses utilisées mg/kg	Effets bénéfiques démontrés chez
17 – méthyletestostérone	0,2 — 1	Saumon Atlantique, Sockeye, Coho, Quinnat, truite arc-en-ciel
Testostérone	5 — 10	Coho, Quinnat
11 – ketotestostérone	1 — 10	Quinnat
Oxyméthalone	1 — 10	Coho
Éthylestrenol	2,5	Saumon atlantique
Estradiol	1 — 10	Coho

SOURCE: Donaldson **et al**, 1979; McBride **et al**, 1982.



Dénomination des pertes	Nature des pertes	Caractère polluant	Possibilité de diminution par l'alimentation
digestives	matières solides et dissoutes	OUI	OUI
excrétion branchiale et urinaire	$NH_3 + NH_4^+$ urée	OUI	OUI
extra chaleur	chaleur CO_2 H_2O	NON	OUI
entretien et activité	chaleur CO_2 H_2O	NON	?



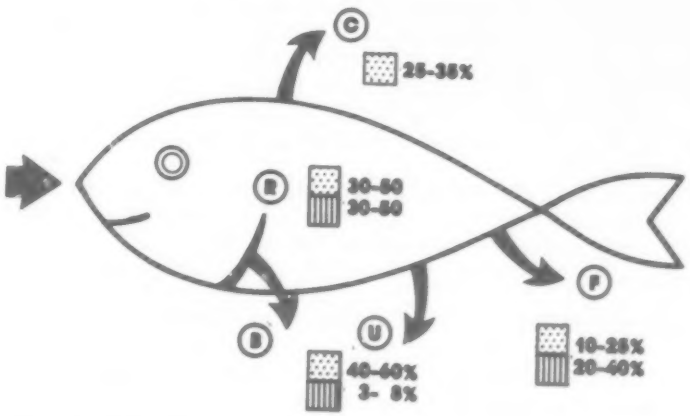


FIGURE 1:

BILANS AZOTÉ ET ÉNERGÉTIQUE CHEZ LES POISSONS. ON PEUT INTERVENIR SUR LES DIVERSES PERTES (F: FÉCALE, B: BRANCHIALE, U: URINAIRE ET C: EXTRA CHALEUR) POUR AMÉLIORER LA RÉTENTION (R).

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BREEDING FOR COLD WATER AQUACULTURE

par G.W. Friars

The use of selection and mating systems, which go together like "hand and glove," has been very effective in increasing the productivity of both plants and animals. The application of such technology to fish has come into prominence in the last couple of decades. Early results indicate that the adaptation of time-tested breeding systems, from conventional agriculture, have significant potential in fish.

Canadian resources are extensive with respect to both fresh and saltwater. However, low temperatures, throughout much of the year, limit the practice of aquaculture in many of these bodies of water. The innovation of means with which to circumvent such a limitation is paramount in the successful development of a fish farming industry. Although the use of approaches and technologies such as seasonal marketing, waste heat, heat pumps, heat exchangers and geothermal heat (Anderson, 1986) have potential, applications of breeding practices can make an important contribution. This paper is directed toward a review of literature, with a view to developing specific strains of different species that could increase productivity in cold water environments.

ANTIFREEZE PROTEIN

The term "genetic engineering" has emerged in recent years in connection with recombinant DNA. Some aspects of this technology are being applied in fish and are mentioned here as a possible future adjunct to the application of selection and mating systems.

The work of Palmiter **et al** (1982) successfully transferred growth hormone fusion genes from one species to another. This work has spurred the imagination of animal scientists with respect to possible approaches to applied problems. However, many contend that the use of appropriate selection and mating systems will have to be coupled with the new technology in order to ensure worthwhile results.

The work of Fletcher (Pers. Comm.) is attempting to transfer an antifreeze protein of winter flounder to Atlantic salmon. The lower lethal temperature for the flounder has been reported to be as low as −1.4°C (Duman, 1974) and may be lower in light of the seasonal cycles in polypeptide antifreeze in the plasma (Fletcher **et al**, 1980). In contrast, the lower lethal temperature for the Atlantic salmon in seawater, of 30 parts per thousand salinity, is −0.7°C (Saunders **et al**, 1975). The implications of this work are exciting but fundamental problems relative to the transfer of antifreeze properties between these two species still need to be worked out, particularly the incorporation of antifreeze DNA sequences into the chromosomes of salmon.

Encouragement for applications of this type of work have appeared in the publication of Chourrout **et al**. (1986) where they state that, "A plasmid containing human growth hormone cDNA sequence was injected into cytoplasm of fertilized rainbow trout (**Salmo gairdneri** Rich.) eggs before first cleavage." and "These data suggest that transgenic trout can be routinely obtained in large proportions".

These new areas of genetic engineering may eventually become an ally of the breeding techniques that represent the time-tested genetic engineering discussed in the following sections of this paper.

POTENTIALS FOR GENETIC GAINS IN GROWTH THROUGH SELECTION

The coefficient of variation for such traits as size and growth rate is generally much higher in aquatic than in terrestial species (Gjedrum, 1975). The fact that practical proportions of this variation are heritable (Gjedrum, 1983; McKay **et al**, 1986 and Bailey, **et al** 1986) makes gains from selection feasible. In fact, evidence of correlated genetic gain for fry size has been demonstrated with a control and a selected line of Atlantic salmon selected for grilse length (Friars **et al**, 1986). Hence, the time-tested gains from selection, realized in conventional agricultural plants and animals, can be reasonably expected in aquacultural species.

The highly variable results obtained in selection experiments (Bohn **et al**, 1983 and Patterson, **et al**, 1983) point to the facts that:

1. Large populations of at least 20 pairs of effective parents, that leave reproductive offspring, need to be involved in each population. To meet this criteria of effective parents, many more parents may need to be involved, particularly in the case of family selection mentioned later.
2. Selection needs to be carried out for more than one generation.

The expected gain also depends on the proportion of the population selected. The selection applied by Friars **et al** (1986) is portrayed in Figure 1. The mean of the proportion selected for October grilse length was 1.75 standard deviations above the general mean of the population, a level that has allowed genetic gain in many agricultural species. The results already mentioned for fry length indicate that this intensity of selection was also effective here.

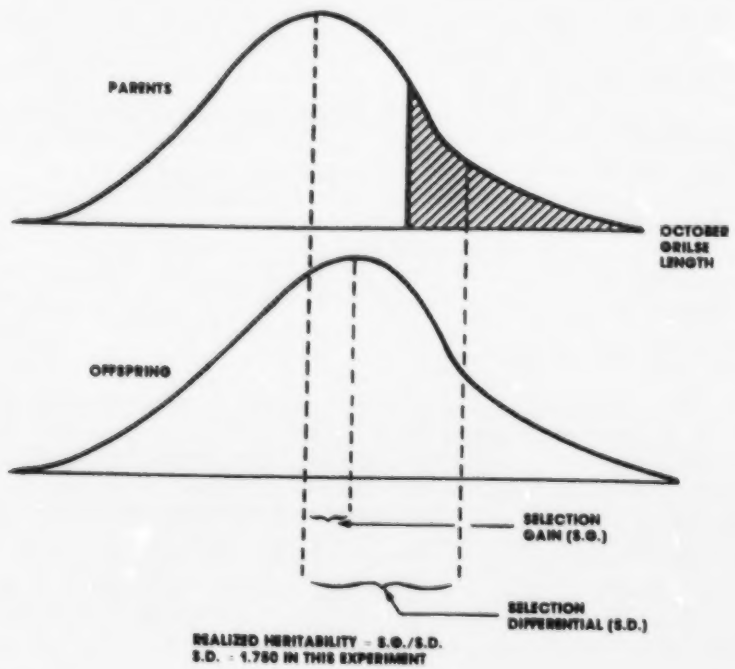

FIGURE 1:
TRUNCATION SELECTION DEPICTING REALIZED HERITABILITY.

The randomization of environmental effects, such as differences between cages or tanks, across genetic effects such as families, becomes difficult (Friars, **et al**, 1986). Where families must be kept in separate tanks or cages, because of inadequate techniques for making individuals — a serious problem in fish — the use of selection within families may be necessary. In such cases, the expected genetic gains attained by selecting the best individuals from each family are practical (Doyle, **et al**, 1986).

Selection on the basis of family performance will be required where traits are lowly heritable or are only measurable on an individual's relatives. The latter case was experienced with resistance to furunculosis at the Salmon Research Centre. Survival in 42 families, with 100 individuals each, ranged from 18 to 98 percent. Matings were made with siblings of the fish that experienced the disease, where they had been placed in a sea cage prior to the outbreak. Progeny from matings of individuals from high-resistance families were compared with low-resistance counterparts, where these offspring were challenged with the furunculosis organism at Department of Fisheries and Oceans Laboratories in Halifax. There was some tendency for progeny of the highly-resistant families to withstand the challenge better. In fact, two of the families were very resistant. These results suggest that the possibilities for the development of disease-resistant strains are real as in the case of the Marek's disease in chickens (Friars **et al**, 1972).

Combinations of between-family and within-family selection may be required in some instances, particularly where more than one trait has to be considered. For instance, selection for size might be applied on a within-family basis in conjunction with between-family selection for disease resistance. The use of indexes with which to evaluate the aggregate genetic merit, over all traits considered, may be required.

SELECTION IN SHELL FISH

Newkirk (1983) observed that a high degree of phenotypic variation existed in oysters. A high level of heterozygosity at isozyme loci was associated with fast growth. There was a question as to whether the advantages of this heterozygosity could be combined with selection. The opportunities for improvement through the application of breeding techniques are apparent.

Mallet **et al** (1986a) has tested stocks of blue mussels (**Mytilus edulis**) collected from different locations in Prince Edward Island and Nova Scotia. The collected stocks were transplanted at several locations. Grow-out site differences accounted for most of the variation in tissue growth but growth in shell weight and length were explained by both rearing site and stock. Mortality (Mallet **et al**, 1986b) was affected by rearing site, stock and season. The use of breeding technology in this species, then, appears feasible.

MATING SYSTEMS

The principle danger in mating systems rests with inbreeding. Although the development and testing of specific crosses of inbred lines can be productive, the resources required are probably beyond the reach of most organizations involved in fish breeding. The detrimental effects of inbreeding on reproduction and viability have been documented (eg. Lerner, 1958). Similarly, the interference of inbreeding with selection progress has been demonstrated (Jui **et al**, 1974). Selection systems, then, need to be exercised with a view to minimizing inbreeding.

The avoidance of high levels of inbreeding can be accomplished by subdividing populations into different locations, cages or blocks of cages

(Fig. 2). The transfer of milt each generation greatly reduces the chances of close relatives both contributing gametes to a mating. With four-year generation intervals, as in the case of salmon, it would take 12 years for three transfers to get a gene from a sperm to the population from which it was originally sampled. This system could be accommodated without a complicated marking or recording system. However, duplicate systems of marking to avoid loss of identification might be helpful, eg. branding and tagging.

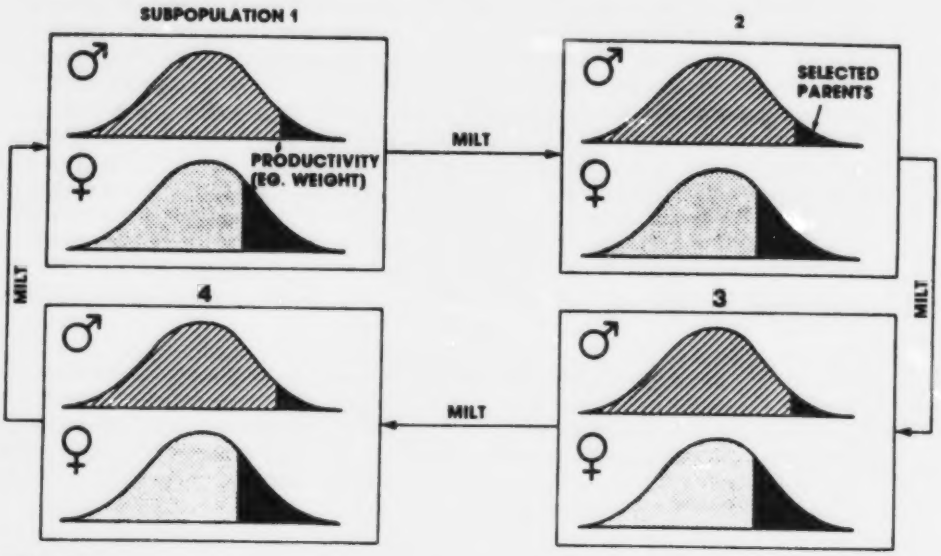

FIGURE 2:
PASSAGE OF MILT BETWEEN SUBPOPULATIONS AT EACH GENERATION INTERVAL TO MINIMIZE INBREEDING.

The number of effective parents, as mentioned in the selection considerations, must be high to avoid serious inbreeding. Since inbreeding is cumulative, this consideration is important at the time of starting a population as well as in later generations. The fact, that fish have larger numbers of eggs per female than most agricultural species, raises the temptation to use fewer parents per generation. In a random mating population, the increase in inbreeding should be below a safe level with 20 pairs of effective parents whose offspring reproduce at the formation of the next generation.

Other mating systems such as strain crossing within a species might be desirable as demonstrated in turkeys (Friars **et al**, 1962). However, the results with fish have been less striking (eg. Friars **et al**, 1979 and Hörstgen-Schwark 1986), where perhaps the gene pool has not been narrowed through applied breeding.

COMPARISONS OF SPECIES AND STRAINS WITHIN SPECIES IN WARM AND COLD WATER ENVIRONMENTS

Broodstock or strain differences in growth rate have been reported in many species. Problems surrounding the comparisons of stocks, lines or families have been discussed by Gall (1983). Sadler **et al**. (1986) cite the importance of the effects of temperature on growth rate for three species and one hybrid. The combined effects of temperature and genetic effects (such as specie, strain or family) lead to consideration of a phenomenon

known as genotype x environment interaction, brought to prominence by Haldane (1946). An exploitation of this phenomenon would allow the development of specific gene pools to perform in certain environments such as cold water.

The elevation in specific growth rate, when ambient water temperature was 16°C as opposed to 10°C, was much more pronounced for brook trout than for lake trout (Fig. 3) in the work of Sadler (1986). Splake, a cross of brook and lake trout, was intermediate in this respect as was rainbow trout. Hence, brook trout represented the poorest growth candidate at 10°C but the best at 16°C. This result implies that the choice of species for a specific temperature regime may be a primary consideration in aquaculture.

The strains within a species are worthy of note (Fig. 3). The boost in specific growth rate, due to a shift from 10°C to 16°C, is greater for the fastest growing strain in the case of both rainbow and brook trout. Therefore, the choice of strain within a species may be as important as the selection of a species for the particular temperature to be used in a given environment.

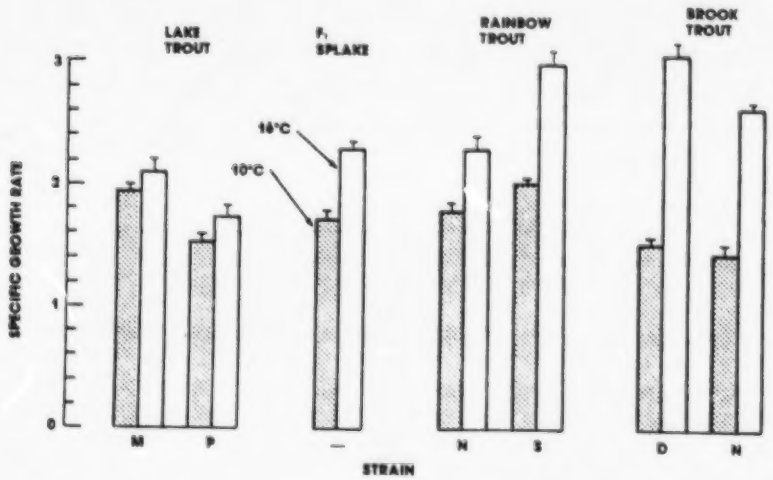

FIGURE 3:
SPECIFIC GROWTH RATES OF TROUT STRAINS AT TWO TEMPERATURES WITH UPPER 95% CONFIDENCE INTERVALS (From: Sadler, S.E., G.W. Friars and P.E. Ihssen, 1986. Can. J. Anim. Sci. 66: 599-606).

Another interesting piece of research with respect to the comparison of species for aquacultural performance was reported by Glebe **et al** (1986). Hybrids of Arctic char and Atlantic salmon were compared with Atlantic salmon, with a view to combining the fast growth of char during the juvenile stage in fresh water with the salinity tolerance of the salmon during their marine growth phase. The fresh water growth phases were promising for the hybrids but high levels of salinity during subsequent grow-out in marine cages caused significant mortalities. Selection for improved salinity in strains of char may improve seawater tolerance of their hybrid progeny.

Sterility of the hybrids holds some promise, where growth gets directed toward marketable meat rather than reproductive tissue. This is accomplished by heat schocking the salmon eggs that have been fertilized with char milt. Such sterility holds considerable potential for the protection of primary breeders

that have made large expenditures on selected lines, since growers cannot reproduce the stock. Primary breeders, in areas such as the poultry industry, distribute genes from their selection programs to franchise hatcheries that use specified mating systems. These hatcheries are contractually obligated to use the primary stock. Where sterility is not involved in poultry as in fish, attempts to reproduce from crosses have given poor results.

FAMILY X TEMPERATURE INTERACTION

McKay **et al** (1984) compared the growth of 35 full sib families of rainbow trout at two water temperatures, 7°C and 15°C, where the mean changes in fork length per week were 2.95 mm and 4.45 mm in the two environments respectively. The 7°C water temperature was selected because it is fairly close to ground water temperature in Southern Ontario, whereas 15°C is close to the optimum for growth. The important point is that the top five families, for gain in fork length at 7°C, ranged in rank from seventh to thirtieth position at 15°C (Table 1). This would imply that the families with the genes to perform well at 7°C are not the ones that will do the best job at 15°C. Hence, it would appear feasible to develop gene pools that are required to produce at specific temperatures.

TABLE 1:

RANKS OF FAMILIES FOR GAIN IN FORK LENGTH AT 7°C AND 15°C.
(Data from McKay, L.R., G.W. Friars and P.E. Inssen, 1984) AQUACULT. 41: 131-140

	Temperature	
	7°C	15°C
	1	8
	2	12
	3	11
	4	30
	5	7
	Families 6 to 30 not shown	
	31	21
	32	14
	33	28
	34	27
	35	35

1. The ranks listed under 15°C are for the same families that had the corresponding rank at 7°C.

The poorest families, which ranked 31st to 35th at 7°C scored no better than 14th at 15°C. This implies that there is some tendency for certain families to perform poorly in either the cold or warm environments. The specific set of genes for superior performance in 7°C water should, then, perform somewhat satisfactorily at 15°C. On the other hand, there is justification for selecting gene pools in the environment in which such fish are to perform ultimately. However, breeding programs are expensive and attention may need to be paid to the development of stocks that perform well over a range of temperatures and other environmental variables.

Genetic gain for a trait, such as growth rate in a second environment when selection is applied in another environment, depends on the heritability of the trait in each environment and the genetic correlation between the performances in the two environments. Using such information in rainbow trout, McKay **et al** (1984) found that, if rapid growth in length at 7°C is the goal, indirect selection on performance at 15°C would be only .58 as effective as direct selection in the 7°C environment. The generation interval would be expected to be longer in the cold water environment but would have to be

more than 1.7 times as long to favour indirect selection. Hence, the expected genetic gain has to balance the costs involved.

SPECIAL STOCK FOR SEA-CAGE CULTURE OF ATLANTIC SALMON

The sea cage industry, in the Southwest Bay of Fundy, has experienced very rapid growth in recent years. The breeding work required to develop suitable strains has only begun. However, some evidence for the superiority of the Saint John River stock over the Big Salmon River fish has emerged (Saunders **et al** (1983) and Saunders (In Press)). The difference between these two stocks is manifested through the Big Salmon River stock having a higher incidence of grilse (sexual maturation after one sea winter) as opposed to multiple-sea-winter salmon. The early sexual maturity impedes growth and distracts from flesh quality. Where the Saint John River stock has a ratio of grilse to multiple-sea-winter salmon close to 1 to 1 in nature, the proportion of grilse is usually below two percent in sea cages. Even though the grilse-to-salmon ratio in the Big Salmon River stock is as high as 17.5 to 1 in the home river system, it falls in a range as low as .09 to 1 and sometimes as high as 1 to 1 in cages. Nevertheless, the frequency of grilse makes this stock undesirable for current sea-cage market requirements. These requirements are for a six-to-nine pound fish after two summers and part of a second winter in cages. However, certain markets in Europe are now calling for a fish in the two-to-three pound range. Stocks with a high incidence of grilse may, therefore, have a place in areas where they can be marketed prior to the onset of sexual maturity. Such marketing strategies may also have a place in sites where salmon cannot be over-wintered due to lethal cold temperatures.

Sterilization of stocks through the use of triploidy, as mentioned with the species crosses, and possibly other methods of sterilization can also by-pass the grilse problem. The objectives of fast growth to sizes such as six to nine pounds in Atlantic salmon may then become simpler.

The genetic relationships between growth rates in different parts of the growth curve is an area that needs to be studied, particularly with respect to the ability to reach the smolt stage in 1+ instead of 2+ years. Environmental enhancement of this process and other aspects of growth, through such treatments as extended photoperiod in the Fall season (Saunders et al, 1985), complement genetic gains and make the selection process simpler.

The question of whether all families react similarly to such an extended photoperiod is pertinent. This problem is being investigated by a graduate student, Alex Hanke, at the University of New Brunswick (Saint John), who is doing thesis research at the Salmon Research Centre, St. Andrews. The phenomenon is another aspect of genotype x environment interaction. The results should indicate whether a special strain will be required to respond to such photo-stimulation.

SUMMARY

The potential for genetic gains in cold water aquacultural species are good. The choice of species or hybrids to fit certain areas of Canada's cold water environment represents a prime consideration in the establishment of stocks. The choice of strains within a species appears to be almost as important as the decision on a particular species. Furthermore, the heritable variation within strains points to the feasibility of developing vastly improved stocks for specific purposes, such as cold water rearing.

The role of hybridization of species together with the involvement of chromosome engineering, particularly triploidy, has promise in counteracting

sexual maturation where it is undesirable in production systems. Similarly, the place of antifreeze proteins, growth hormones and other biochemical entities could become significant in the future. The involvement of these new technologies will probably have to be used "hand-in-hand" with proven selection and mating techniques.

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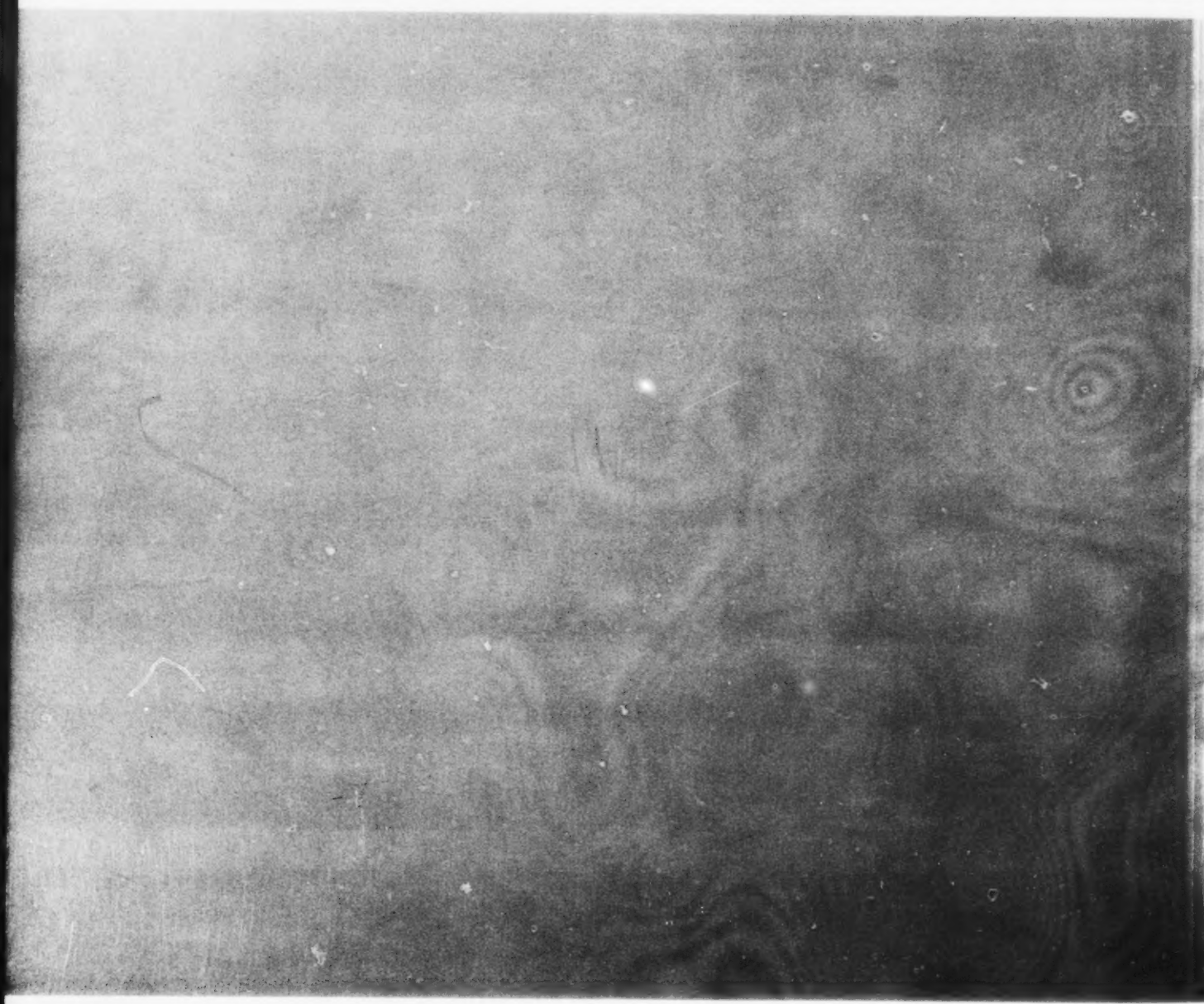

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